This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

HW 28D2 B

Digitized by Google

KE 801

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

THE

WHEAT PLANT:

ITS ORIGIN, CULTURE, GROWTH, DEVELOPMENT,
COMPOSITION, VARIETIES, DISEASES,
ETC., ETC.

TOGETHER WITH A FEW REMARKS ON

INDIAN CORN, ITS CULTURE, ETC.,

BY JOHN H. KLIPPART,

Corresponding Secretary of the Ohio State Board of Agriculture; Member of the Academy of Natural Sciences, Cleveland; Honorary Member of Western Academy of Natural Sciences, Cincinnati, and Corresponding Secretary of Columbus Scientific Association.

ONE HUNDRED ILLUSTRATIONS.

CINCINNATI:
MOORE, WILSTACH, KEYS & CO.,
25 West Fourth Street.
1860.

Digitized by Google

KE 801
~~KF 926~~

HARVARD
UNIVERSITY
LIBRARY
JUL 21 1941

Shelton Fund

Entered according to Act of Congress, in the year 1859,
BY MOORE, WILSTACH, KEYS & CO.,
In the Clerk's Office of the District Court of the United States for the Southern District of Ohio.

Digitized by Google

PREFACE.

SEVERAL years ago I became aware of the fact that wheat—the staple crop of Ohio—was annually diminishing in its yield per acre; that in less than fifty years the average product was reduced from thirty to less than fifteen bushels per acre. I also learned that, in Great Britain the yield had increased from sixteen bushels to thirty-six per acre during the same period. A knowledge of these facts induced me to investigate the subject of wheat culture, as well as the collateral subjects, in order to ascertain the cause of the decrease on the one hand, and the increase on the other, as well as to learn what remedy, if any, might readily be applied to restore our soils to their former productiveness. The result of this investigation is embodied in the present volume.

I am not aware that any apology is necessary for introducing this volume imperfect as it necessarily is, to the agricultural public. To me it has been a matter of surprise that no American has produced a treatise on the wheat plant; and more than all that, even professional agricultural writers have been content to leave the "scattered fragments of thought" on so important a topic as the physiology, culture, varieties, diseases, etc., of the wheat plant dispersed through a multitude of journals or serial publications. That portion of the present volume published in the Ohio Agricultural Report, for 1857, caused the entire edition of 20,000 copies to be absorbed in less than sixty days from the date of publication. The urgent solicitation of personal friends, in the correctness of whose judgment I have the utmost confidence,

Digitized by Google

again indicated to me a want, which I had previously seriously felt, of a work which should embrace all that is known relative to the wheat plant. Such a work I have endeavored to produce; and this work is now presented to the public with the assurance that there is no other work in the English language so complete on all subjects relating to this indispensable cereal.

In Germany, Metzger, in the early part of this century, wrote a concise natural history of the European cereals; in 1836, Rev. F. W. Krause published an elegant and profusely illustrated work on German Wheats, Rye, Barley, and Oats; and within the past ten years, a Mr. Kœnig published a small work on Cereals and German Forage Plants.

John Le Couteur, some thirty years ago, published a work on wheat, in which most of the British varieties, which at that time were cultivated, are described.

But these transatlantic works are of suggestive value only to American agriculturists, because not a single variety grown in England, Germany, or France, has been successfully introduced into the United States; and the system of culture practiced in those countries differs as widely as does the climate.

The study of the wheat plant is the study of a lifetime. I have endeavored to trace the origin and history of this most important cereal, and it is much to be regretted that the origins of all the cereals are hidden under such an impenetrable veil. So far as the growth, the physiology of the plant is concerned, I have been careful either to verify every statement which is contained in this book, or else obtain it from such authority as to render verification unnecessary, excepting always the experiments of Salm Hortsmarr, which consisted entirely in growing plants in artificial inorganic soils,—those of Gilbert and Lawes, and those of Liebig. I had instituted a series of experiments similar to those of Sir Sidney Godolphin Osborne, when, fortunately for me, his report to the

Digitized by Google

Microscopical Society of London came into my possession; since which time nearly all of his experiments have been repeated by me. In describing the growth of the wheat plant, I was necessarily obliged to discuss vegetable physiology, and notwithstanding this portion of the book may appear dull and uninteresting, and hypothetical only, yet it is one of the most important subjects to the agriculturist.

On all doubtful points I have consulted the best authorities to which I could obtain access, and have availed myself of the advantages offered by a constant and close attention to the best American, English, German, and French agricultural periodicals. No one can be more sensible than the writer, that much matter obtained from these sources has been too hastily digested for publication.

The origin, composition, condition and management of soils naturally present themselves from many standpoints, in all of which it is necessary to discuss them; so that from the very nature of the case it is impossible to prescribe on a single page the precise method to be pursued in any given case, as a physician would prescribe for the measles; but it has been deemed more practical to examine the constituents of soils and plants, and the action of soils on plants, and that of plants on soils. Having thus stated the proposition, everyone will discover how far the examinations and results are applicable to his own estate.

The descriptions of wheats in Ohio were obtained from prominent practical agriculturists throughout the State; and the engravings of wheat heads were drawn from actual specimens now in the Cabinet in the State Agricultural Rooms.

The descriptions of insects affecting the wheat plant were obtained from all accessible authentic sources, many of them, especially the engravings from Morton's Encyclopedia of Agriculture. To the best of my knowledge that portion relating to the diseases of the wheat plant, whether by vegetable or animal parasites is the most complete compilation

Digitized by Google

accessible. There are many who, no doubt, desire greater simplicity of language, or freedom from technicalities or scientific terms. On that account I have endeavored to express every idea in as simple and concise a manner as possible; at the same time scientific and technical terms are almost indispensable.

Finally, if this work will induce our agriculturists to adopt an improved system of culture, so that the average product shall again attain its former maximum, the most sanguine wishes of myself, publisher and friends, will be fully realized.

JOHN H. KLIPPART.

STATE AGRICULTURAL ROOMS,
Columbus, O., Sept. 10, 1859.

Digitized by Google

CONTENTS.

PAGE.

PREFACE 8

INTRODUCTION 9

CHAPTER I.

General View of the Organic World 17

CHAPTER II.

Cereals and Grasses 36

CHAPTER III.

History of the Wheat Plant 59

CHAPTER IV.

Origin of the Wheat Plant 92

CHAPTER V.

Structure and Composition of the Wheat Grain 107

CHAPTER VI.

Germination of the Wheat Plant 126

CHAPTER VII.

Origin and Constituents of Soils 153

CHAPTER VIII.

Nutrition of the Wheat Plant 176

CHAPTER IX.

Experiments of Salm Horstmarr on the growth of Plants in Inorganic Artificial Soils; also, those of Weigmann and Polstorff. 210

CHAPTER X.

Experiments of Gilbert and Lawes 289

Digitized by Google

PAGE.

CHAPTER XI.

Growth of the Wheat Plant 266

CHAPTER XII.

Botanical Description of the Wheat Plant 280

CHAPTER XIII.

Wheat Regions of the World 290

CHAPTER XIV.

Culture of Wheat 330

CHAPTER XV.

Exhaustion of Soils 352

CHAPTER XVI.

Management of Soils 389

CHAPTER XVII.

Improvement of Soils 426

CHAPTER XVIII.

Description and Classification of Varieties of Wheat 479

CHAPTER XIX.

Wheats in Ohio 512

CHAPTER XX.

Diseases and Enemies of Wheat 557

CHAPTER XXI.

Animal Parasites affecting the Wheat Plant 592

CHAPTER XXII.

History of Corn 641

INDEX 693

Digitized by Google

THE

WHEAT PLANT.

It has frequently been asserted that the enactment of laws and the institution of schools were unmistakable evidences of civilization. True it is that these can exist only in societies that are not only civilised, but are also in a greater or less degree enlightened and refined; but even many of the barbarous nations and savage hordes have laws of their own making, and many civilized communities were innocent of schools.

But there is an evidence of civilization other than social institutions and mental development, an evidence grasped from Nature, and with her kind assistance, and fostering care, perpetuated by civilized man only.

That true and unequivocal symbol of civilization, and consequent enlightenment and refinement is, the WHEAT PLANT. As truly as did flocks of sheep in the primitive ages lead the shepherds to the threshold, of that truly magnificent science, Astronomy, just so certainly did the wheat plant in yet earlier ages induce man to forget his savageism, abandon his nomadic life, to invent and cultivate peaceful arts, and lead a rural and, consequently, peaceful life. There is not on the vast expanse of the face of the globe a savage, barbarous, or semi-

Digitized by Google

civilized nation that cultivates the wheat plant. In the settlement of New England, the Indians called the plantain the "Englishman's foot," and in the infancy of society wheat may have been similarly regarded as springing from the footsteps of the Persians or Egyptians. Our Aborigines fully appreciated the influence of the wheat plant on society, if the following anecdote, related by *Crevecœur*, the old French traveler, has any foundation in fact: The chief of the tribe of the Mississais said to his people, "Do you not see the whites living upon seeds, while we eat flesh? That flesh requires more than thirty moons to grow up, and is then often scarce. That each of the wonderful seeds they sow in the earth returns them an hundred fold. The flesh on which we subsist has four legs to escape from us, while we have but two to pursue and capture it. The grain remains where the white men sow it, and grows. With them winter is a period of rest, while with us it is the time of laborious hunting. For these reasons they have so many children, and live longer than we do. I say, therefore, unto every one that will hear me, that before the cedars of our village shall have died down with age, and the maple trees of the valley shall have ceased to give us sugar, the race of the little corn (wheat) sowers will have exterminated the race of the flesh-eaters, provided their huntsmen do not resolve to become sowers."

The ancients, who had burst the bonds of savageism, and scarcely more than escaped from the confines of barbarism, and through the magic influence of the fruit of the wheat stalk barely reached the threshold of civilization, retained a grateful memory of the plant, which was the prime cause of their amelioration; they erected temples and instituted an appropriate rite for the worship of the goddess Ceres, who was

Digitized by Google

by them regarded not only as the patron goddess of the crops, but the propitiator of sound morals, and the promoter of peace and peaceful avocations.

In their traditions of the wars of the giants, the ancient Germans have a legend, the purport of which is, that Thor, the agriculturist, obtained possession of the soil from Winter, who had depressed, brutalized, scattered, and destroyed the inhabitants with his chilling blasts and storms of sleet and snow, and drenching showers of rain, upon condition that he would introduce harmony, peace and fellowship into social life by the culture of straw-producing plants.

The culture of the wheat-bearing plant compelled the cultivator to abandon the wild or nomadic life which it is not unreasonable to suppose he must have led, and the time which otherwise would have been spent in roaming through the forests, was now spent in contriving indispensable implements; first and prominent among these were the plow and harrow—rude beyond question in mechanical structure, and uncouth in appearance, yet they were the first peaceful, and at the same time utilitarian products of civilization.

These implements compelled man to employ the physical strength of animals, which have ever since been his constant companions. First, the ox was domesticated, and to labor under the yoke became his daily task; next, the horse, that noblest of quadrupeds, was not only tamed and taught to come at the call of his master in the morning, but to endure the heat and fatigues of the day. Thus, a great work accomplished, and the second great step taken toward ultimate civilization, as well as the superiority of man over the beast and brute fully established when the sheep, the ox, the cow, and the horse retired together to rest at twilight in the rude

Digitized by Google

shed, or open field, and the faithful watch-dog sought his accustomed post as sentry.

Thus has the culture of this straw-growing plant caused savages to abandon their barbarous customs—has fixed in friendly communion many nomadic and rival hordes—inaugurated the greatest era the world ever saw, the era from which the human race may date its incipient civilisation, the era of labor. The continued culture and increase of this plant has from the very commencement called into action all the resources of civilised nations. After the invention of the plow and harrow, man's inventive genius was tasked to produce a reaping hook or sickle, and successively during the many ages of the historic period has this plant called into existence the scythe, the grain cradle, winnowing machine, sowing machine, thrashing machine, and within our own day and generation, the reaping machine. The prolificacy of this plant has brought into existence the cart and the wagon in the earlier ages of society, but in more recent ones it has demanded the construction of turnpikes, and macadamized roads through the pathless wilderness; that canals be dug to unite the waters which flow to the Northward with those which flow to the equator; that boats be constructed, and ships with wide-spreading canvas were found to be indispensable; and lastly, the steamboat, steamship, railroad and steam flouring-mill were as loudly and as earnestly demanded in our day as was the rude plow in the first days of civilisation.

There is not in the entire catalogue of plants another one which has been as instrumental in the development of mechanical ingenuity, and the intellectual faculties, as has been, and is, the wheat plant. It is true that fiber-producing plants and prominently among these flax and cotton, have exercised

Digitized by Google

considerable influence in the development of mechanical inventions, but upon strict examination it will be found that very many of the principles of mechanical structures and combinations of powers had already been called into requisition by the fiber produced by the sheep, and the thread produced by the silk-worm.

In countries where the agricultural art, or rather the culture of the wheat plant, has fallen into disuse, there has civilization also retrograded; and were it not for commerce with enlightened and refined nations, several countries would speedily relapse into all the horrors of absolute barbarism. Were the wheat plant "blotted out of existence," society would of necessity revert to its original state. In vain would the miner delve in the bowels of the earth to bring forth the dark and heavy ore to make iron; no iron would be wrought because there would be no use for plows, and consequently no use for the thousand mechanical contrivances for sowing, harvesting, thrashing, cleaning, transporting and grinding wheat. Is it not astonishing to reflect on the number of persons engaged in the culture of the plant, the number engaged in constructing and improving machinery to gather and prepare the seed, the number engaged in transporting the grain from place to place, as well the number engaged in the manufacture of flour, and the preparation of bread. Truly is not the wheat the plant, the corner-stone of civilization, and would not the destruction of it overwhelm society with darkness blacker than the storm cloud at midnight. Does the extreme cold of winter destroy the germ of the stalk in the plant—have the rains been too frequent and too abundant—or has a pitiless and heartless hail-storm leveled it to the earth; then how many are the thousands to whom is brought

Digitized by Google

suffering, and sorrow, and hunger. In the grave of the past are buried revolts and insurrections, wild as hordes of savages in their demonstrations, and terrible in their course as the lava current bursting from the bowels of the earth, which have been the lamentable results of an unpropitious season or seasons, in which the straw of the wheat plant failed to attain a proper maturity and perform its natural functions. Brute force has been called into requisition, plunder and even murder has been committed by the sufferers, who know no law other than necessity, when the cereals fail.

While the hands of industry are busily employed in securing the product yielded by the wheat plant, every one is eagerly and earnestly shaping his demand for a *pro rata* of the results. This one has closeted himself, and buried himself in the study of law; that one has seized the pencil or the chisel; another has taken to the jack-plane; a fourth has mounted the fearful locomotive; a fifth has entrusted himself to the treacherous waves of the briny deep; a sixth has picked up the sledge, whose uses were taught to mankind by Vulcan, and from sun to sun strikes the patient anvil; all, all having a single and identical object in view, namely, *that of exchanging the fruits of their labors for the fruits of the wheat plant;* thus is the action of society kept in a continual round of exchange like a bark on a sluggish eddy, forever departing from the shore only to be forever arriving at it, and forever arriving only to be forever departing. The pearl-fisher dives fearlessly into the fathomless deeps of the ocean for the animal product found among the rocky polyp-trees; the miner excavates the subterranean shaft for gold, the artists produce articles of the most exquisite workmanship, and like a beast of burden the porter tenders the services of his physical

Digitized by Google

strength in order to obtain a proportion of the products of the wheat plant. All that we see or hear, all that is done, all that is spoken, written or thought, is performed directly or indirectly on account of the fruit of that plant, which introduced, developed, and to-day maintains civilization.

It may be said that this is claiming too much for a cereal whose origin has scarcely ceased to be a matter of controversy. With a map of the world before you, point, if you can, to the country or nation enjoying civilization and enlightenment, that does not cultivate the cereals, or point to a country or a nation in a state of savageism or barbarism that does cultivate the wheat plant; then reflect for a moment on the number of persons in our country whose occupation would be gone; how many millions of capital would have been uselessly invested, how many machines and implements would be left to decay in inglorious idleness, and how much calamity, moral, political and social would ensue, were the wheat plant to be suddenly and universally annihilated.

Digitized by Google

Digitized by Google

A TREATISE

ON THE

ORIGIN, GROWTH, DISEASES, VARIETIES, ETC., OF THE WHEAT PLANT.

CHAPTER I.

GENERAL VIEW OF THE ORGANIC WORLD.

As barbarism and ignorance gave place to civilization and enlightenment, new fields of investigation, and consequently new sources of enjoyment presented themselves, and attracted the attention of the learned in all ages. Prominently among the most interesting of these fields of research and investigation, were natural phenomena, and at a very early period in the history of mankind do we find great attention paid them. From the many ferocious, and at that time uncontrollable wiid beasts, the study of the animal kingdom engaged the attention of the learned. In the ages of greater comparative refinement in the history of civilization, we find the greatest attention bestowed on the vegetable kingdom; it has attracted the attention of all classes; as much, perhaps, from the beautiful, variously tinted and fragrant flowers with which it fascinates, as from the more substantial elements of food which it furnishes.

In the enlightened, or present scientific age—the age of scrutinous investigation—the age in which the microscope has revealed to us the wonders of the miniature world, as did the telescope, in a former age, the Planetary world—the age

Digitized by Google

which, when future historians record its events, may truthfully say, that during this period, every organic and inorganic substance within the reach of man was submitted to chemical analysis, and the elements composing them determined even in almost infinitesimal detail—this age was the first to devote any special attention to the mineral kingdom.

Among the various and manifestly distinct races of animals, naturalists observed that many analogous characteristics existed between individuals, which evidently were the offspring of separate and widely distinct progenitors. A very strong resemblance in external conformation—the structure of the hoof as well as the shape of it—the tail—head—hair or covering, etc., were observed in the Horse, Ass, Zebra, and Quagga. Because of this resemblance, naturalists at a very early day placed all these animals just mentioned into one group, and called it the *Horse* group, or genera, and every animal belonging to this group is said to be of the Horse kind or *genus*. The Lion, Tiger, Leopard, Cat, and other animals with long stiff hairs on the upper lip—the foot divided into toes, and that crouch and spring upon their prey, are said to be of the Cat kind, or genus. In this manner have naturalists arranged in groups all the known animals in the world. The groups like the Horse group or Cat group are named GENERA, and the individual varieties or kinds composing the group are named *species*. In cases where several genera have analogous characteristics, they form a grand group which is named *Order* or *Family;* then analogous Orders are arranged into CLASSES.

In the vegetable kingdom a similar arrangement into classes, orders, genera and species has obtained, founded, however, on qualities and characteristics differing in kind only from those of the animal kingdom. Botanists make two grand divisions of the entire vegetable kingdom :—the one is composed of all the flowering or Phænogamous plants, and the other of the flowerless or Cryptogamous ones. The flowers of the flowering

Digitized by Google

plants serve as the basis of a system of classification into genera and species. No one who has observed can fail to notice the great similarity that is presented by the flowers of the radish, cabbage, mustard, turnip, candy-tuft, pepper-grass, and horse-radish; all these and many more are called the Turnip Family, or CRUCIFERÆ. Not only is there a great resemblance between the flowers of the pea, the bean, vetch and lupine, but the fruit of each of these is encased in a similar pod or legume; hence these plants are by botanists placed in the same group, and called the Pea Family, or Leguminosæ. In a similar manner have all the known plants been classified by Linnæus, and other botanists.

The vegetable kingdom is further divided, or rather subdivided into Exogens and Endogens, or those plants which increase by annual layers between the bark and heart wood, as the oak, hickory, etc., and those which do not so increase, as the Indian corn, wheat, oats, etc. These two divisions are further subdivided into *Monocotyledonous*, or plants whose seed is an entirely solid mass, as a grain of wheat, rye, or corn; and *Dicotyledonous*, or plants whose seed are composed of two portions, as the bean, acorn, chestnut, etc.

So, also, has the mineral kingdom been analyzed and classified; the distinguishing feature of the groups being a predominance of a certain mineral, metal or earth in the composition of any individual of the group. Alabaster, Plaster of Paris, Epsom Salts, Satin Spar, Marl, etc., belong to the Lime Family, because lime predominates in their composition; the Topaz, Ruby, Emerald and Alum are arranged under the head of Alumina, on account of the predominance of the last named mineral in the composition; and Quarts, Agate, Jasper, Amethyst, Sand and Onyx under that of Silica, because *Flint* is the basis of these gems.

It is now claimed by one party of theorists, that including the fossils of the animal and vegetable kingdoms, there may be traced a series of progressive forms of development, com-

Digitized by Google

mencing with the simplest crystal on the one hand, and becoming thenceforward not only more complex, but more highly organized as the series progresses, till man is produced, who at once is the most complex, most highly organized, and the crown of the series of organic creations. The reader is respectfully referred to a work entitled the "VESTIGES OF CREATION," for a full exposition of this singular theory.

Geology and Palæontology teach us to regard our planet as a body subject to changes not dissimilar to youth, manhood and age—subject to an almost organic system of development. In this respect there appears to be somewhat of a parallel between organic and inorganic worlds. The inorganic was first in point of time—organic existence could necessarily take place only after the inorganic was created. In tracing the progress of development of organized matter, we are led to conclude that primitive vegetation was at all events aquatic, if not actually marine; but in process of time there were distinct land, as well as distinct water or aquatic plants. The remains of plants, which we find in the lowest series of rocks containing fossils, are therefore the earliest types of the vegetable kingdom, and strange to say, from the very limited number of plants found fossil in comparison to those now in existence, the fossil ones present the chief types of the present vegetable kingdom—the monocotyledons only are wanting. In the fossil coal we find faint indications of them; but in the subsequent Geological periods, the New Red Sandstone for example, we find a plant belonging to the class of *Restiaceæ*—a class allied to the Rushes—Mr. Brogniart has named this plant *Polœoxyris regularis.* In the Kemper formation we find a plant Polœoxyris Munsteri, which greatly resembles the former one.

It is in the Lias, however, that we find the first true grasses: Poacites Arundo. Paspalum and Nardus; of the Cyperaceæ or *sedges*, we find cyperites scirpoides, caricinus, and typhoides.

In the Miocene formation we find Culmites anomalus,

Digitized by Google

Brogn., and C. Göpperti, and Bambusum Sepultum, *Ung.*; and finally, in the Pliocene, we find Culmites arundinaceus, *Ung.*, and Cyperites tertiarius, *Ung.*

The limited number of the above exceedingly rare species which have been found, are undoubtedly but a mere fraction only of the species which existed during those respective periods of the earth's history.

What a singular history could be written did we know *all* the genera and species of plants which existed during the entire pre-Adamite history of the globe! Possessed of this knowledge, we would be able to trace with certainty the history of each particular species; indicate in an unerring manner the *nativity* of each plant, and classify with greater precision.

But we know sufficiently of the order of creation as indicated in the rock formations of the earth, to feel certain that the primitive plants were of the Algæ tribe; then followed the Ferns, sigillariæ, asterophyllæ; then succeeding them came coniferæ and cycadæ; while in *our* time the dicotyledonous plants preponderate.

There is a singular order of development in the vegetable kingdom viewed as a whole, those of a simpler organization appearing first, and the more complex ones appearing at a later period. Among the monocotyledons the grasses at present predominate, while the compositæ present the greatest number of species of dicotyledonous plants. There is good reason to infer from this fact, that the several families of plants did not and do not exist independent of each other without a specific purpose, and that the entire vegetable world is an unit, and its development in the different periods of creation is in accordance with an immutable law—the vegetation of the various epochs have a certain relation and connection with each other.

Prof. Unger has elaborated a beautiful hypothesis with relation to the vegetable world, in which he compares the exist-

Digitized by Google

ence of a species with that of an individual plant. Even as an individual plant has a period of commencement, a period of perfect development, as well as a period of decay; so, also, does a species have a period of commencement, a point of culmination in development, and a period of termination. Thus far we may adopt, with perfect security, the theory advanced by Prof. Unger, because it is corroborated by researches in palæontology or fossil geology; but, when he asserts that "the plant is subject to a period when it may produce a new species, similar to the impregnation and development of seed in a single individual," it is best to hold assent in abeyance.

It is by no means difficult to demonstrate where the mineral kingdom terminates, and the vegetable or animal kingdom commences, because the transition from inorganic to organic forms must necessarily be very abrupt; but naturalists assert that it is an exceedingly difficult task to draw the line of demarkation between the vegetable and animal kingdoms. Many species of Radiata or the lowest types of the animal kingdom are now classed as *Anthozoa*, especially the *campanularia* and *alcyonium*, and more recently the entire class of Porifera or Sponges have been regarded as belonging to the vegetable kingdom. If the series of progression are as regular and as perfect as theorists assert, then must all the intermediate links between any specified points in the series also be perfect; and upon this hypothesis of perfection in the series it is claimed that nature endeavors to prevent the propagation of mules or hybrids, in the animal kingdom, by regarding them as excrescences, and withholding from the reproductive organs the performance of their proper functions.

In the vegetable kingdom, although there is considerable conflict between the different systems of classification, so far as genera and species are concerned, yet, as a whole, it is claimed that there exists as perfect a chain of progressive development as in the animal;—from the simple cell of the Red Snow or *Protococcus* up to the most elegantly and highly or-

Digitized by Google

ganized Phænogamia. Hence it is confidently asserted, that although the vitality in plants is very distinct from, and lower in the scale of organization than that of the animal kingdom; and although in their most highly organized forms, plants are susceptible of being wrought upon and greatly changed by man's interference, such as inarching, budding, and grafting not only different varieties of the same species upon each other, but upon widely different species themselves, have these operations proved successful; yet, notwithstanding the tenacity of life in the lowest orders of the animal kingdom, success has never crowned any experiments where different species have been attempted to be grafted upon each other, although polyps of the same species have been engrafted on each other.*

Much has been accomplished as man has become more familiar with the laws of nature, but more especially with physiological laws, in the improvement and more perfect development of individuals, by special care and attention to the natural wants and habits of plants and animals, and by modifying conditions of temperature, climate and nutriment, in

* If the head of a polyp, with all its tentacles, be cut off from the trunk with scissors, it will presently develop a new trunk and base, while the headless trunk begins to shoot out new tentacles; and thus, in a little time, two perfect animals are formed. If one of these be cut in three, four, or half a dozen pieces, each piece supplies the wanting parts, and so many animals are made, all as perfect and active, and endowed with the same functions as the first. Nor does it signify in what direction the mutilation is made; a longitudinal, a diagonal, or a transverse division is equally successful; nay, even a small portion of the skin soon grows into a polyp. It was from this power of perpetual reproduction that this singular animal received the name of *Hydra*, by which it is known among naturalists; as if it realized the ancient monster of fabulous story, whose heads sprouted anew as fast they were cut off by Hercules.

Most curious monstrosities were produced by the experiments of philosophers on these animals, especially by partial separations. If a polyp be slit from the summit to the middle, one will be formed having two heads, each

Digitized by Google

accordance with the laws governing the respective kingdoms. In the natural state the ox measures in girth from five to six feet, and weighs from ten to twelve hundred pounds; but, by attention and conformity to physiological laws he has been so improved (?) as to measure from nine to ten feet in girth, and to weigh upward of three thousand pounds. By a strict adherence and obedience of these laws, certain desirable characteristics have been obtained and perpetuated, insomuch that these qualities obtained by cultivation have given rise to artificial varieties in the horse, ox, sheep and hog. The fleetest racer, as "*Flora Temple*" or "*Lady Suffolk*," as well as the heavy and uncouth Norman draft horse, may trace its parentage through many lapses of time, perhaps, and countries, until it centers in one and the same progenitor; but they owe their distinctness and modification of form to climate, care and conformation, to natural and physiological laws. So the Shorthorns, Longhorns, Herefords, Devons, etc., are undoubtedly the offspring of one and the identical progenitor; but climate, locality, and attention have modified and molded them into remarkably distinct artificial varieties.

There is no difficulty in proving that the original Saxony sheep was a very coarse-wooled and uncouthly formed animal, and now owes its present fineness of wool entirely to man's agency; and to the same cause are due the various qualities of wool and artificial varieties of sheep. The China, Berk-

---

of which will capture and swallow food. If these again be slit half a dozen times, as many heads will be formed surmounting the same body. If now all of these be cut off, as many new ones will spring up in their place, while each of the severed heads becomes a new polyp, capable of being in its turn, varied and multiplied *ad infinitum*,—so that in every respect our little reality exceeds its fabulous namesake. Polyps may be grafted together. If cut off pieces be placed in contact, and pushed together with a gentle force, they will unite and form a single one. The head of one may thus be placed on the trunk of another.—*Life; by P. H. Gosse.*

Digitized by Google

shire, Essex, Suffolk, Grass Breed and other varieties of the hog, owe their peculiarities to man's instrumentality, and are undoubtedly the modified offspring of one common pair of parents.

The improvements above named may with great propriety be termed "*developments*," for there is no doubt each individual in the animal kingdom above mentioned was innately susceptible of these improvements, and all that was necessary to make them manifest was to be surrounded by the proper condition and influences.

But man has, in some instances, endeavored to make an improvement in another direction. He observed that the product of the symmetric thorough-bred horse upon the massive draught or Norman horse, was an animal less symmetric than the one, yet lighter than the other; slower than the one, yet fleeter than the other; in a word, the characteristics of both were blended and united in this offspring. This new animal then became the progenitor of a new sub-variety of horses. Finding that the cross thus produced realized the most sanguine anticipations, a cross was determined on between the horse and the ass, the result was the mule; but it could not propagate its species. In the many attempted improvements by crossing, the following law was discovered: That a cross between two individuals of the same species, although of different varieties, is a MONGREL, partaking of the form and characteristics of both progenitors, and is capable of reproduction, as in the case of the cross of the turf and draft horse just stated; but the product of two animals of different species or zoölogic circles is a MULE, partaking in a greater or less degree of the paternal or maternal type, but entirely deprived of reproductive powers.

In the vegetable kingdom the results are precisely analogous to those in the animal. The individual plants which participated in the crossing may be distinctly traced in the hybrid. The varieties obtained by crossing affiliated plants or

Digitized by Google

flowers produce fruits which have fecundating powers, familiar instances of which may be found in corn, portulaccas, convolvulus or morning-glory; while the hybrids or crosses produced by the artificial impregnation of flowers produce no fruit, or at most, if fruit is produced, the seeds are sterile. Flowers appear to possess a much stronger attraction for the pollen or fecundating property of the male portion of the plant, of their own varieties, than for that of different species; hence, in order to be successful in hybridizing, it is not only very essential that a large quantity of the pollen be employed, but it is also necessary that the flowers be closely allied; crosses between individuals of different genera, or different species although of the same genera, produce no result. It is also useless to attempt to produce crosses with those plants whose seeds never mature in this climate.

It may not, in this place, be irrelevant to say a few words in detail of the hybridization of plants. The earliest record we can find of hybrids is in the writings of Camerarius, in 1694. Linnæus wrote his "*Dissertation de plantis Hybridis*" in 1751, and eight years later Kolreuter commenced and succeeded in producing hybrids by artificial fecundation: from this last named period to the present time numberless species and genera of plants have been submitted to the process of hybridization, which in itself is exceedingly simple.

This process consists in bringing the pollen which is contained in the anthers of the one flower into contact with the stigma of the pistil of the flower intended to be impregnated.

As the parts of plants will frequently be referred to in the course of the work, it will not, in this place, be very inappropriate to explain the process of hybridization, as well as the parts or anatomy of flowers.

FIG. 1 represents a glume or husk of wheat, magnified six diameters, containing the male and female parts of the flower in their natural although immature positions. FIG. 2 repre-

Digitized by Google

sents a glume magnified twelve diameters, and in a more advanced stage. *d* is the *ovule*, or unimpregnated seed or body destined to become a seed; or, perhaps, more properly, the young wheat grain. *e e* the pistils, or female part of the flower. Many flowers, as the convolvulus or morning-glory, have *one* pistil only; the family of grasses to which wheat belongs has, as a general thing, two pistils; the common elder, sumach, etc., three; the elatine, or water-wort, four, etc., etc. The pistils are always in the center of the flower, and are attached or surmounted on the ovule or ovary, to which they serve as ducts for the pollen grains. *a c c* are anthers, or the male part of the flower, and contain pollen grains, which latter contain a fluid that impregnates or fecundates the ovule; that portion marked *b* is termed filament or thread, from its thread-like form, and connects the anther to the ovule or glume, as the case may be. The entire organ *a b* is called a *Stamen*.

Fig. 1.*

When the *anthers* arrive at *a*, Fig. 3, or *c*, Fig. 2, they become ruptured, and shed the pollen grains upon the pistils of the glume which they are leaving; but do not shed their pollen upon other glumes after they have escaped from the parent glume, as has erroneously been asserted. One *anther* only escapes at a time. Figs 3, 1, and 2, were drawn from nature; 1 represents the interior condition of the glume at the proper time for hybridizing, *i e.*, before its own anthers

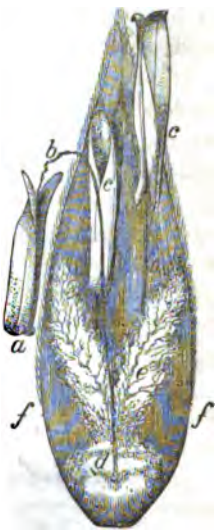


Fig. 2.†

* Fig. 1. Glume of wheat exhibiting pistils and anthers in situ.

† Fig. 2. Glume of wheat in bloom, magnified twelve diameters, and in a more advanced stage. *a.* Ruptured anther. *b. b.* Filaments. *c. c.* Anthers not yet extruded. *d.* Ovarium, or young grain of wheat. *e.* Pistil. *f. f.* Glume.

Digitized by Google

have shed their pollen. Fig. 2 exhibits the glume after one anther (*a*) has escaped, and another (*c*) partially extruded, while Fig. 3 represents the two anthers as having escaped

Fig. 39.

Fig. 40.

Fig 41.

and emitted their pollen, while *a* is partially extruded. Hence, since one anther only escapes at a time, it would be impossible for the anthers of one glume to fecundate the germs in a neighboring glume; except, indeed, it be demonstrated that the sides of the glume remain apart for such purpose. Those who may be disposed to take the pains to examine will find that the sides of the glumes are in such exceedingly close proximity as to exclude even the finest particles from entering. The exit of the anthers always takes

---

* Fig. 3. Glume of wheat exhibiting the sexual apparatus of the flower. *a*. Anther partially ruptured and extruded. *b*. Anthers entirely extruded and ruptured. *e*. Filaments. *d*. Ovarium. *c*. Anthers as they appear before extrusion commences. ☞ The pistils are removed in this figure, to avoid confusion.

† Fig. 4. A portion of the pistil highly magnified. *f. f f*. Pollen grains.

‡ Fig. 5. A small portion of the pistil very highly magnified. *b. c*. Portion of Pistil. *a*. Main cavity or duct leading from extremity of pistil to *ovarium*. *d*. A pollen grain penetrating a branch of the main duct.

Digitized by Google

place at the upper portion of the glumes, so that the pollen, by its own gravity, falls directly upon the pistils.

After a pollen grain has fallen among the tufted portion of the pistil, as at *f*, Fig. 4 (which represent a portion of the pistil, *e*, Fig. 2, highly magnified), it soon becomes exceedingly plastic. The pistil as well as the pollen grain is covered with an exceedingly thin coat of mucilaginous matter, which causes them to adhere when once in contact. The fimbria of the pistil contain ducts through which the pollen grain finds its way until it reaches the ovule, where it finds bodies having a greater affinity for its contents, which are soon commingled with the surrounding parts. Fig. 5 represents a portion of the pistil very highly magnified, with a pollen grain, *d*, penetrating a branch of the main duct, *a*.

There are certain conditions, however, which must be strictly observed, otherwise there can be no successful impregnation: the flowers with which it is proposed to operate, must have obtained the same degree of advancement, because impregnation can not be effected on others than those flowers which expand or bloom at about the same time. The pollen grains are a very fine dust contained in a very delicate envelop in the anther of a stamen—the color of the pollen varies with the species, but as a general thing is of a pale yellow tint — those of the morning-glory are of a pearly white, while those of the cucumber family are a deep yellow. Each pollen grain contains, within an exceedingly delicate, transparent membrane, a mucilaginous material, which is inodorous, and is the fecundating substance of the male organ. The pistil ordinarily has a small spongelet surrounding the center of the style, called the stigma, which is lubricated by a serous liquid, which has in an eminent degree the power of absorption. If, upon the extremity of this stigma, a small drop of colored liquid—for example, in the morning-glory the pistil is white, use a liquid colored with carmine—the absorbing powers manifest themselves very strikingly, for the style will be colored down to its base. Now the passage which thus becomes

Digitized by Google

colored, is the duct which the pollen enters and traverses in the phenomenon of fecundation.

When it is desired to obtain a hybrid from hermaphrodite flowers, the first thing to be done is to remove the anthers; this is best performed early in the morning, because the dew has swollen the anthers and prevents the opening of the little sac, which contains the pollen; the simplest method of removing the anthers is to use a pair of very small scissors or forceps. Then at, or toward noon, carefully remove the anthers from the flower with whose pollen we wish to impregnate, and shake them gently so that the pollen dust may fall upon and adhere to the stigma of the flower from which the anthers had been removed in the morning. The heat of the day produces a dilatation of the pollen, and thus facilitates its dispersion.

In order, then, to hybridize, it is necessary to take the heads of wheat which are intended to be the parents, both male and female, when they have arrived at that state of maturity indicated by Fig. 1, or *before* any of the anthers have escaped from the glume. Suppose a cross is intended to be consummated between the Genessee Flint, as male, and White Blue Stem, as female. Then, on a dry and warm day—this state of weather seems to be necessary, as at such times impregnation not only more readily takes place, but appears to be more successful—between 10 and 12 o'clock, hold the head of the Blue Stem downward, and carefully open the glumes; then with a very sharp pointed scissors, cut off the anthers (*a c c*, Fig. 2), and let them fall to the ground; great care must be taken that no anther is permitted to touch the pistil of the same head, either before or after separation of the filaments (*b b*, Fig. 2); this is perhaps the most delicate part of the operation. After the anthers have been removed, pollen-grains from the anthers of the Genessee Flint must be immediately applied to the pistil of the glumes from which the anthers have been removed.

In order to preserve the heads thus impregnated, from

Digitized by Google

injury by insects or birds, they may be enveloped in a hood of gauze, or Swiss muslin, but no caution whatever, is necessary to guard against the accidental introduction of pollen-grains, as Mr. D. J. Browne intimates in the Patent Office Report for 1855, page 184, viz:

"The three males are designed to impregnate the stigma of the one female, or pistil, which is situated in the center of the anthers. From these anthers, a powder, or pollen, is emitted, which adheres to, or is absorbed by, the stigma, and is conveyed by it down to the berry, or seed, at its base, and thus effects the work of fecundation. So decided is the preference of the pistil for the pollen of its own stamens, that it is often impossible to impregnate it with that of any other head, while a particle of this is near. Impregnation takes place best when the weather is dry and warm, as a peculiar warmth, and a certain electric state of the atmosphere prepare the parts for this process, which always occurs on a dry day. The opinion, indeed, has been expressed, that the pollen of the male conveys hydrogen to the ovules of the female, that oxygen is received from the atmosphere, and carbon, in the form of carbonic acid gas, from the roots; and that, when the pollen is destroyed by the rain, or from any other cause, the carbon alone is found in the ear, and this is the well known 'smut' in wheat. That pollen of the stamen is essential to impregnation is at least certain; and it is almost as certain, from what has been stated, that the total destruction of the reproductive power of a particular race of wheat must be effected, before the influence of another can be felt. Two races being placed together, therefore, a cross can only be certainly effected by clipping the anthers from all the stamens of one variety, and leaving the work of impregnation to be effected by those of the other exclusively. This may be done by any person capable of distinguishing between the two races; but, perhaps, the safer guide to this distinction consists in sowing the two in separate drills, very near each other say nine or ten inches apart; and, to render the work still

Digitized by Google

more sure, there should be no other growing wheat within at least a quarter of a mile of that experimented upon, the affinity between the pollen and the ovules being of almost incredible force. A series of experiments can only be made, therefore, by the co-operation of several experimenters, or of a few occupying farms of considerable magnitude; yet they ought to be conducted according to a plan of perfect unity of design."

"Watchful care should then be taken to protect the patches or drills from disturbance by vermin or fowls, while still in the ground, and afterward from insects and birds. The use of gauze nets would be by no means superfluous, from the moment that the heads begin to form. As soon as the anthers show their first rudiments, in a race upon which the cross is to be made, they should be carefully removed, or clipped with a pair of sharp scissors, leaving the female organs undisturbed. Thus both races would be impregnated with the pollen of one. When matured, the utmost care should be taken to gather the seeds of the crossed race by itself."

Hybridization is an operation requiring dexterity, a light and steady hand, and it has been frequently remarked, that the operation is more uniformly successful when performed by a female. Many singular facts with regard to the structure of flowers have been discovered through attempts to hybridize. In the common nettle the stamens have elastic filaments which are at first bent down so as to be obscured by the calyx; but when the pollen is ripe, the filaments jerk out, and thus scatter the powder on the pistils which occupy separate flowers. In the common barberry the lower part of the filament is very irritable, and whenever it is touched the stamen moves forward to the pistil. In the stylewort the stamens and pistils are united in a common column, which projects from the flower; this column is very irritable at the angle where it leaves the flower, and when touched it passes with a sudden jerk from one side to the other, and thus scatters the pollen.

It frequently happens in gardens, that there are accidental crosses, which may be attributed to divers causes, but as a

Digitized by Google

general thing owe their origin to the agency of insects, bees, bugs, etc. These accidental crosses happen most frequently in the cabbage tribe. Double flowers, like the chrysanthemums, are always sterile, and the hybrids, as a matter of course, can not reproduce; but Mons. Gallesia has produced double flowers, by crossing semi-double with semi-double ones, and has succeeded in obtaining fertile seed from semi-double and even double ranunculus! Hybrids have been produced by horticulturists between the *ox-heart* and the morello cherry, also between the damson plum and the wild bullace-tree. Annexed is a list of plants which have been found to produce hybrids in their wild or uncultivated state, and without the agency of man:

MALE PARENT.	FEMALE PARENT.	HYBRIDS.
1. Festuca Elongata, (*Spiked Fescue*)	Lolium perenne, (*Eye-grass, or Darnel*)	Festuca Loliacea.*
2. Scirpus Lacustris, (*Lake Bull-rush, round stem*)	Scirpus triqueter, (*Triangular Rush*)	Scirpus Duvalii.
3. Nigritella angustifolia, (*Orchid*)	Gymnadenia odoratissima,	Nigritella suaveolens.
4. Ophrys muscifera,	Ophrys aranifera,	Ophrys hybrida.
5. Salix fragilis, (*Willow with smooth ovaries*)	Salix alba, — (*White Willow with glabrous ovaries*)	Salix Russelliana.
6. Salix fragilis,	Salix triandra,	Salix speciosa.
7. Salix purpurea,	Salix viminalis, (*Basket Willow*)	Salix rubra.
8. Salix purpurea,	Salix cinerea,	Salix Pontederana.
9. Salix purpurea,	Salix repens,	Salix Doniana.
10. Salix viminalis,	Salix caprea,	Many hybrids.
11. Populus alba, (*Silver-leaf Poplar*)	Populus tremula, (*Aspen*)	Populus canescens.
12. Rumex palustris, (*Dock*)	Rumex obtusifolia, (*Broad leaved*)	Rumex Steinii.
13. Inula Germanica, (*Elecampane*)	Inula ensifolia,	Inula hybrida.
14. Carduus nutans, (*Thistle*)	Carduus acanthoides,	
15. Cirsium arvensi, (*Canada Thistle*)	Cirsium palustre,	Cirsium chailleti.
16. Cirsium cano,	Cirsium oleraceum,	Cirsium tataricum.
17. Hieracium præalto, (*Hawk-weed*)	Hieracium pilosella,	Hieracium bifurcum.
18. Hieracium villoso,	Hieracium murorum,	Hieracium villoso murorum.

*The seeds of this plant are invariably imperfect—this fact led botanists to suspect that it was a hybrid.

Digitized by Google

MALE PARENT.	FEMALE PARENT.	HYBRIDS.
19. Hieracium alpinum,	Hieracium murorum,	Hieracium alpino murorum.
20. Gallium verum, (*Madderwort*)	Galium mollugo,	Galium ochroleucum.
21. Mentha sylvatica, (*Mint*)	Mentha aquatica,	Mentha nepetoides.
22. Verbascum thapsus, (*Mullein*)	Verbascum phlomoides,	
23. Verbascum nigra,	Verbascum austriacum,	
24. Verbascum specioso,	Verbascum orientale,	
25. Verbascum specioso,	Verbascum phœniceum,	
26. Veronica anagallis, (*Brooklime*)	Veronica beccabunga,	
27. Primula integrifolia, (*Primrose*)	Primula minima,	Primula Florkenna.
28. Erysimum hieracifolium, (*Phlox wall-flower*)	Erysimum canescens,	Erysimum virgatum.
29. Nasturtium amphibium,	Nasturtium sylvestre,	Nasturtium austriacum.
30. Rosa canina,	Rosa rubiginosa,	Rosa sepium.
31. Geum urbana, (*Avens*)	Geum rivale,	Geum intermedium.
32. Medicago sativum,	Medicago falcate,	Medicago media.

Professor Gærtner, of Stuttgardt, and A. Neilreich, of Vienna, having devoted much time to the study of this subject, state that the cereals are among the plants least favorable to hybridization. Professor John Lindley, professor of Botany in the University College, London, does not regard the process by any means as impracticable, but merely difficult in manipulation—in removing the expanded anthers, and then applying the pollen of another. Mr. Maund, of Bromsgrove, Warwickshire (England), obtained a prize medal at the industrial exhibition in London, in 1851, for hybrid specimens produced from the annexed varieties of wheat:

MALE.	FEMALE.	HYBRID.
1 Old Lammas,	Donna Maria,	An ear larger than either parent.
2. Pearl White,	Oxford Red,	Do. do. do.
3. Clustered Red,	Satin White,	Coarse, rough, short ear.
4. Old Lammas,	Kings' White,	Very large, long ear.
5. Boston Red,	Donna Maria,	Large ear, very strong straw.
6. White Cone (hairy),	Northumberland Red (smooth),	Long, beardless ear, rather downy.
7. Dark Cone,	Pearl,	Small, deformed, white ear.

Mr. Maund found, as a general rule in hybridizing wheat,

Digitized by Google

that a strong male and weak female produced a better result than a weak male and a strong female.

In 1848, Mr. Raynbird, of Laverstake, obtained a gold medal from the Highland (Scotland) Society, for experiments of this kind. Mr. R. commenced his experiments in 1846, with the "*Hopetoun*," a white wheat, of long ear and straw, and fine grain, and "*Piper's Thickset*," a coarse, red wheat, with thick clustered ears, a stiff straw, and very prolific, but liable to mildew. The hybrids thus obtained, were intermediate between the two parents—the ears are shorter than in the "*Hopetoun*," and larger than in the "*Thickset*."

Digitized by Google

CHAPTER II.

CEREALS AND GRASSES.

Of all the plants now so universally diffused over the surface of the globe, the grasses are of the first importance to man. From them he derives all the essentials of life. The cereals, embracing a portion only of the family of grasses, are to man in his civilized condition more important than the other classes of the grasses. They contain the elements to form, bone, muscle and fat. Almost every family of plants contain some which are deleterious in their effects when eaten, from which general rule the ceralia are not exempt. One plant, the Lolium temulentum, is said to be poisonous.*

As nothing can be uninteresting which is connected with the habits of a tribe of such vast importance to man, I extract the following account of the geographical distribution of grasses by Schouw, from Jameson's Philosophical Journal for April, 1825: "The family is very numerous; Persoon's Synopsis contains 812 species, one twenty-sixth part of all the plants therein enumerated. In the system of Roemer and Schulres there are 1,800; and, since this work, were it brought to conclusion, would probably contain 40,000 in all, it may be assumed that the grasses form a twenty-second part. It is more than probable, however, that in future the grasses will increase in a larger ratio than the other phanerogamic plants; and that, perhaps, the just proportion will be as one to twenty, or as one to sixteen. Greater still will be this proportion to vegetation in general, when the number of individuals is taken into account; for, in this respect the greater number, nay, perhaps, the whole of the other classes are inferior; with regard to locality in such a large family, very little can be

* For a detailed account of this plant see Burnett's Outlines of Botany.

Digitized by Google

advanced. Among the grasses there are both land and water, but no marine plants. They occur in every soil, in society with others, and alone; the last to such a degree as entirely to occupy considerable districts. Sand appears to be less favorable to this class; but even this has species nearly peculiar to itself. The diffusion of this family has almost no other limits than those of the whole vegetable kingdom. Grasses occur under the equator, and Agrostis algida was one of the few plants which Phipps met with on Spitsbergen. On the mountains of the south of Europe, Poa disticha and other grasses ascend almost to the snow line; and, on the Andes, this is also the case with Poa malulensis and dactyloides, Deyeuxia rigida, and Festuca dasyantha.

"The greatest differences between tropical and extra tropical grasses appear to be the following: 1. The tropical grasses acquire a much greater hight, and occasionally assume the appearance of trees. Some species of Bambusa are from fifty to sixty feet high. 2. The leaves of the tropical grasses are broader, and approach more in form to those of other families of plants. Of this the genus paspalpus affords many examples. 3. Separate sexes are more frequent in the tropical grasses. Zea, Sorghum, Andropogon, Olyra, Anthistiria, Ischæmum, Ægilops, and many other genera, which only occur in the torrid zone, and are there found in perfection, are monœcious or polygamous. Holcus is, perhaps, the only extra tropical genus with separate sexes. 4. The flowers are softer, more downy and elegant. 5. The extra tropical grasses, on the contrary, far surpass the tropical in respect to the number of individuals. That compact grassy turf which, especially in the colder parts of the temperate zones, in spring and summer, composes the green meadows and pastures, is almost entirely wanting in the torrid zones.

The grasses there do not grow crowded together; but, like other plants, more dispersed. Even in the southern parts of Europe, the assimilation to the warmer regions in this respect, is by no means inconsiderable. Arundo donax, by its hight,

Digitized by Google

reminds us of the Bamboo, Saccharum Ravennæ, S. Teneriffæ, Imperata Arundinacea, Lagura Ovatus, Lygeum Spartum, and the species of Andropogon, Ægilops, etc., by separate sexes, exhibit tropical qualities. The grasses are also less gregarious, and meadows seldomer occur in the south than in the north of Europe. The generality are social plants.

The distribution of cultivated grasses is one of the most interesting of all subjects. It is not merely governed by climate, but depends on the civilization, industry and traffic of the people, and often on historical events. Within the northern polar circle, agriculture is found only in a few places. In Siberia, grain reaches at the utmost only to 60°, in the eastern parts, scarcely above 50°, and in Kamstchatka there is no agriculture even in the most southern parts (51°). The polar limit of agriculture, on the northwest coast of America, appears to be somewhat higher; for, in the more southern Russian possessions (57° to 52°), barley and rye come to maturity. On the east coast of America, it is scarcely above 50° to 52°.

Only in Europe, namely, in Lapland, does the polar limit reach an unusually high latitude (70°). Beyond this, dried fish, and here and there potatoes, supply the place of grain. The grains which extend furthest to the north in Europe are barley and oats. These, which in the milder climates are not used for bread, afford to the inhabitants of the northern parts of Norway and Sweden, of a part of Siberia and Scotland, their chief vegetable nourishment. Rye is the next which becomes associated with these. This is the prevailing grain in a great part of the northern temperate zone, namely, in the south of Sweden and Norway, Denmark, and in all the lands bordering on the Baltic; the north of Germany and part of Siberia. In the latter, another very nutritious grain, buckwheat, is very frequently cultivated. In the zone where rye prevails, wheat is generally to be found; barley being here chiefly cultivated for the manufacture of beer, and oats supplying food for the horses. To these there follows a

Digitized by Google

zone in Europe, and Western Asia, where rye disappears, and wheat almost exclusively furnishes bread. The middle, or the south of France, England, part of Scotland, a part of Germany, Hungary, the Crimea and Caucasus, as also the lands of middle Asia, where agriculture is followed, belong to this zone. Here the vine is also found; wine supplants the use of beer; and barley is consequently less raised. Next comes a district where wheat still abounds, but no longer exclusively furnishes bread, rice and maize becoming frequent.

To this zone belong Portugal, Spain, part of France on the Mediterranean, Italy and Greece; further, the countries of the east, Persia, Northern India, Arabia, Egypt, Nubia, Barbary, and the Canary Islands; in these latter countries, however, the culture of maize or rice toward the south is always more considerable, and in some of them several kinds of sorghum (douhra) and Poa Abyssinica come to be added.

In both these regions of wheat, rye only occurs at a considerable elevation; oats, however, more seldom, and at last entirely disappear; barley affording food for horses and mules. In the eastern parts of the temperate zone of the old continent, in China and Japan, our northern kinds of grain are very unfrequent, and rice is found to predominate. The cause of this difference between the east and the west of the old continent appears to be in the manners and peculiarities of the people. In North America wheat and rye grow as in Europe, but more sparingly. Maize is more reared in the western than in the old continent, and rice predominates in the southern provinces of the United States. In the torrid zone, maize predominates in America, rice in Asia, and both these grains in nearly equal quantity in Africa. The cause of this distribution is, without doubt, historical; for Asia is the native country of rice, and America of maize. In some situations, especially in the neighborhood of the tropics, wheat is also met with, but always subordinate to these other kinds of grain. Besides rice and maize there are, in the torrid zone, several kinds of grain, as well as other plants, which

Digitized by Google

supply the inhabitants with food, either used along with them, or entirely occupying their place. Such are, in the new continent, yams (Dioscorea alata), the manihot (Jatsopha manihot), and the batatas (convolvulus batatas), the root of which, and the fruit of the pisang (Banana nusa), furnish universal articles of food. In the same zone, in Africa, doura (sorghum), pisang, manihot, yams, and Asachis hypogæa. In the East Indies, and on the Indian Islands, Elusine coracana, E. stricta, Panicum frumentaceum; several palms and Cycadeal, which produce the sago; pisang, yams, batatas, and the breadfruit (Artocaspus incisa). In the islands of the South Sea, grain of every kind disappears, its place being supplied by the breadfruit tree, the pisang, and tacca pinnatifida. In the tropical parts of New Holland there is no agriculture, the inhabitants living on the produce of the sago, the various palms, and some species of Arum.

In the highlands of South America, there is a distribution similar to that of the degrees of latitude. Maize, indeed, grows to the hight of 7,200 feet above the level of the sea, but only predominates between 3,000 and 6,000 of elevation. Below 3,000 feet it is associated with the pisang and the above mentioned vegetables; while, from 6,000 to 9,260 feet, the European grains abound; wheat in the lower regions, and rye and barley in the higher; along with which Chinopodium quinoa, as a nutritious plant, must also be enumerated. Potatoes alone are cultivated from 9,260 to 12,300 feet. To the south of the tropic of Capricorn, wherever agriculture is practiced, considerable resemblance with the northern temperate zone may be observed.

In the southern parts of Brazil, in Buenos Ayres, in Chili, at the Cape of Good Hope, and in the temperate zone of New Holland, wheat predominates; barley, however, and rye make their appearance in the southernmost parts of these countries, and in Van Dieman's Land. In New Zealand the culture of wheat is said to have been tried with success; but the inhabitants avail themselves of the Acrostichum fuscatum as the main

Digitized by Google

article of sustenance. Hence, it appears that, in respect of the predominating kinds of grain, the earth may be divided into five grand divisions, or kingdoms. The kingdom of rice, of maize, of wheat, of rye, and lastly of barley and oats. The first three are the most extensive; the maize has the greatest range of temperature, but rice may be said to support the greatest number of the human race. It is a very remarkable circumstance, that the native country of wheat, oats, barley, and rye, should be entirely unknown; for, although oats and barley were found by Col. Chesney, apparently wild, on the banks of the Euphrates, it is doubtful whether they were not the remains of cultivation. This has led to an opinion, on the part of some persons, that all our cereal plants are artificial productions, obtained accidentally, but retaining their habits, which have become fixed in the course of ages.

The uses of this most important tribe of plants, for fodder, food, and clothing, require little illustration. The abundance of wholesome fæcula contained in their seeds, renders them peculiarly well adapted for the sustenance of man; and if the Cereal Grasses only, such as Wheat, Barley, Rye, Oats, Maize, Rice, and Guinea Corn, are the kinds generally employed, it is because of the large size of their grain, compared with that of other Grasses; for none are unwholesome in their natural state, with the exception of Lolium temulentum, a common weed in many parts of England, the effects of which are undoubtedly deleterious, although perhaps exaggerated; of Bromus purgans and catharticus, said to be emetic and purgative; of Bromus mollis, reported to be unwholesome, and of Festuca quadrudentata, which is said to be poisonous in Quito, where it is called pigonil. To these must be added Molinia varia, injurious to cattle, according to Endlicher; and a variety of Paspalum scrobiculatum, called Hureek in India, which is perhaps the Ghrhona Grass, a reputed Indian poisonous species, said to render the milk of cows that graze upon it narcotic and drastic. It is however uncertain, how far the injurious action of some of these may be owing to mechanical causes, which, in the case

Digitized by Google

of the species of Calamagrostis and Stipa seem to be the cause of mischief in consequence of their roughness and bristles.

In their qualities the poisonous species seem to approach the properties of putrid wheat, which is known to be dangerous. Among corn-plants less generally known, may be mentioned Eleusine cosacana, called Natchnee, on the Coromandel coast, and Nagla Ragee, or Mand, elsewhere in India; Phalaris canariensis, which yields the canary-seed; Zizania aquatica, or Canada Rice; Paspalum scrobiculatum, the Menya, or Kodso of India, a cheap grain, regarded as unwholesome; Setaria Germanica, or Hungarian grass; Pariscum furmentaceum, called Shamoola, in the Deccan; Setaria italica, cultivated in India under the name of Kala kangnee, or kora kang; Panicum millaceum, a grain called Warree in India; and P. pilosum, called Bhadlee; Penscillaria spicata, or Bajree; Andropogon sorghum, or Durra, Doora, Jowarree, or Jondla; and Andropogon saccharatus, or Shaloo, are also grown in India for their grain. A kind of fine-grained corn, called, on the west of Africa, Fundi, or Fundungi, is produced by Paspalum exile; and finally, both the Teff and Toccusso, Abyssinian corn plants, are species of this order; the former Poa Abyssinica, the latter Eleusine tocusso. Even Stipa pennati is said to produce a flour much like that of Rice. The value of grasses, as fodder for cattle, is hardly second to that of their corn for human food. The best fodder grasses of Europe are usually dwarf species; or at least such as do not rise more than three or four feet above the ground—and of these the larger kinds are apt to become hard and wiry. The most esteemed are Lolium perrenne, Phleum and Festuca pratensis, Cynosurus cristatus, and various species of Poa and dwarf Festuca, to which should be added Anthoxanthum odoratum, for its fragrance. But the fodder grasses of Brazil are of a far more gigantic stature, and perfectly tender and delicate. We learn from Nees von Esenbeck, that the Caapim de Angola, of Brazil, Panicum spectabile, grows six or seven feet high; while other equally gigantic species, constitute the field

Digitized by Google

crops on the banks of the Amazon. In New Holland the favorite is the Anthistiria australis, or Kangaroo Grass; in India, the A. ciliata, is also in request. But the most common Indian fodder grass appears to be Doorba, Doorwa, or Hurryalee, Cynodon Dactylon. Gama Grass, Tripsacum dactyloides, has a great reputation as fodder in Mexico; and attention has lately been directed to the Tussac Grass of the Falklands, Festuca flabellata, a species forming tufts five or six feet high, and said to be unrivaled for its excellence as food for cattle and horses. The fragrance of our sweet vernal grass (Anthoxanthum), is by no means confined to it. Other species are Hierochloe borealis, Ataxia Horsfieldii, and some Andropogons; their odor is said to be owing to the presence of benzoic acid. The most famous species are Andropogon Iwasancusa and Schœnanthus—the latter the Lemon Grass of English gardens; A. calamus aromaticus, which Dr. Royle considers the plant of that name described by Dioscorides, and the "sweet cane" and "rich, aromatic reed, from a far country," of Scripture; and the Anatherum muricatum, called Vetiver, by the French, and Khus, in India, where its fragrant roots are employed in making tatties, covers for palanquins, etc.

This fragrance is connected with aromatic secretions, which have, in part, recommended grasses to the notice of medical practitioners. The last mentioned plant (Anatherum muricatum) is said to be acrid, aromatic, stimulating, and diaphoretic; another species, A. Nasdus, is called, because of its quality, Ginger Grass, or Koshel. The roasted leaves of Andropogon Schœnanthus are used in India, in infusion, as an excellent stomachic. An essential oil, of a pleasant taste, is extracted from the leaves, in the Moluccas; and the Javanese esteem the plant much as a mild aromatic and stimulant. The former is one of the Grasse Oils of Nemans, called, in India, Ivasanensa, and described in Brewster's Journal. Many others partake of the same qualities. But it is not merely for their aroma that grasses are used medicinally. A

Digitized by Google

cooling drink is employed, in India, from the roots of Cynodon Dactylon. The hard, stony fruits of Coix lachryma (Job's Tears), have been supposed to be strengthening and diuretic; and the latter quality has been recognized in many others, especially the common Reeds, Phragmites arundinacea, and Calamagrostis, in Europe; Perotis latifolia, in the West Indies, and the Brazilian species of Gynesium. A decoction of Eleusine indica is employed, in Demarara, in the convulsions of infants, according to Schomburg. Donax arundinacea is astringent and subacid. The creeping roots of the Quitch, or Quick Grass, Triticum repens, of Tr. glaucum and pinceum, and Cynodon Dactylon and lineare, have some reputation as a substitute for Sarsaparilla. A decoction of the root of Gynerium parriflorum is used, in Brazil, to strengthen the hair.

Sugar is a general product of grasses. Gynerium saccharoides, a Brazilian grass, derives its name from that circumstance. It exists in great quantity in the sugar-cane (Saccharum officinarum); maize so abounds in it that its cultivation has been proposed in lieu of the sugar-cane; and it is probable that the value of other species for fodder depends upon the abundance of this secretion.

For economical purposes grasses are often of much importance. The strong stems of the Bamboo are employed instead of timber and cordage. The Arundo arenaria, and Elymus arenarious (Marrum Grasses) are invaluable species for keeping together the blowing sands of the seacoast, by their creeping suckers, and tough, entangled roots. The first is employed in the Hebrides for many economical purposes, being made into ropes for various uses, mats for packsaddles, bags, hats, etc. Some of the reeds of Brazil, called Taquarussa, are living fountains; they grow from thirty to forty feet high, with a diameter of six inches; form thorny, impenetrable thickets and are exceedingly grateful to hunters, for, on cutting off such a reed, below a joint, the stem of the younger shoots is found to be full of a cool liquid, which quenches the most burning thirst. Reeds, and other coarse species, furnish

Digitized by Google

in Europe, the materials for thatching. The reeds (sometimes sixteen feet long), from which the Indians of Esmeraldi form the tubes whence they blow the arrows, poisoned with the deadly Urari, or Woorali, are single internodes of the Arundinaria Schomburghii. A coarse but good sort of soft paper is manufactured in India from the tissue of the Bamboo, and the very young shoots of that plant are eaten, like asparagus.

Besides these things, the inorganic products are remarkable. That the cuticle contains a large proportion of silex is proved by its hardness, and by masses of vitrified matter being found, whenever a haystack or heap of corn is accidentally consumed by fire. In the joints of some grasses, a perfect siliceous deposit is found, particularly in a kind of jungle-grass mentioned in a letter from Dr. Moore to Dr. Kennedy, of Edinburg. It is also said, that wheat-straw may be melted into a colorless glass, with a blow-pipe, without any addition. Barley-straw melts into a glass of a topaz-yellow color. The siliceous matter of the bamboo is often secreted at the joints, where it forms a singular substance, called tabasheer, of which see a very interesting account in Brewster's Journal. It was found by Turner, that the tabasheer of India, consisted of silica, containing a minute quantity of lime and vegetable matter. Sulphur exists, in combination with different bases, in wheat, barley, rye, oats, maize, millet, and rice.

A brief sketch of the most prominent cereals, other than wheat, may not be inappropriate in this place.

Rye. (*Secale cereale.*)

This plant is extensively cultivated in continental Europe, where it forms the food of perhaps one-third of the entire population. It is not much cultivated in England, and is now less cultivated in Ohio, and other States, than formerly. It has been supposed to be a native of the island of Crete,* of Candia,† and many other eastern portions of the globe. Karl

* Herman Wagner. † Rhind's Vegetable Kingdom.

Digitized by Google

Koch* asserts very dogmatically, that he found it growing undoubtedly wild in the mountains of the Crimea, especially all around the village of Dshimil, on granite, at the elevation of from five thousand to six thousand feet. In such places its ears are not more than one to two and a half inches long. But it nowhere has been observed in a truly wild state, away from the possibility of escape from cultivation, being sown by the agency of man. The *Secale montanum* has a brittle, hairy rachis, glumes with a short point, and root fibrous. It is found on the gravelly mountains in Sicily. In France is found the *Secale villosum*, also a European species of rye. From the fact that *Secale fragile*, and *S. anatolicum* were found in Armenia, as well as in Asia Minor, some have supposed it to be a native of those places.

There are two *varieties*, only, in general cultivation: viz., the winter, and the spring varieties. In England three *sub*-varieties are grown, viz:

I. *Tyrolese*, or Giant Rye, a kind recently introduced, and coming into use a week or ten days earlier than the common rye. It is, however, considered by some farmers, that the produce is not equal to, nor the feed so lasting, as that of the common; but its earliness more than compensates the flock-master for this defect.

II. *The St. John's Day*, or Midsummer Rye; so called from the time of sowing. It is considerably later in running to ear and ripening, and produces far more root-foliage than the common kind. In France it is often sown at the end of June, and eaten down with sheep in the autumn months, and spring till the latter end of April, when it is allowed to run to seed, and considered to produce an equal or better grain crop, by being so treated, than if cultivated in the usual manner.

III. *Cooper's Early Broad-leafed Rye*, was introduced some twelve or fifteen years ago into England by Mr. Cooper. This sub-variety appears far more productive of *early* feed than any of the others.

* Morton's Encyclopædia of Agriculture.

Digitized by Google

Two centuries ago rye flour, either alone, or mixed with wheaten flour, formed the common bread of the country. Now, this mixture is only partially used. At present, rye is cultivated by our farmers principally that they may draw from it a supply of green food for their flocks.

For this purpose the plants, which are sown in November, are eaten early in the spring, before they begin to spindle, which they will do before the first of March. After this stage of the growth has taken place, the succulent quality of the blade is impaired, it becomes coarse and harsh, and is no longer agreeable to animals. When rye is left to ripen its seeds, these are, for the most part, applied in this country to purposes distinct from human food; one of the uses to which the grain is put being the preparation of a vegetable acid, to be employed by tanners in an operation which they call *raising*, and whereby the pores of the hides are distended, so as to dispose them the more readily to imbibe the tanning principle of the oak-bark, which is afterward applied. Rye, when parched and ground, has been recently used as a substitute for coffee.

It would be difficult, however, to convince any one accustomed to the use of this grateful beverage, that the grain of home production is ever likely to take the place, at least to any extent, of the fragrant Mocha bean.

In fact, rye contains neither the aromatic nor stimulating properties which render coffee so grateful. It was formerly usual to sow rye together with an early kind of wheat. The harvested grain, thus necessarily intermixed, was termed meslin, from miscellanea; it also obtained the name of mung-corn, corruptly from monk-corn, because bread made from it was commonly eaten in monasteries. With the exception of wheat, rye contains a greater proportion of gluten than any other of the cereal grains, to which fact is owing its capability of being converted into a spongy bread. It contains, likewise, nearly five parts in every hundred of ready-formed saccharine matter, and is, in consequence, easily

Digitized by Google

convertible into malt, and thence into beer or ardent spirits; but the produce of this last is so small in comparison with that of malted barley, as to offer no inducement for its employment to that purpose. Rye has a strong tendency to pass rapidly from the vinous to the acetous state of fermentation, and whenever that circumstance has intervened, it would be vain to attempt either to brew or to distil it. Unmalted rye meal is mixed in Holland with barley malt, in the proportion of two parts by weight of the former, with one part of the latter, and the whole being fermented together forms the wash whence is distilled all the grain spirit produced in that country, and known throughout Europe as Hollands, Geneva. There must, however, be some circumstances of a peculiar nature connected with the process, as conducted by the Dutch distillers, since no attempts made elsewhere have ever been successful in obtaining a spirit having the same good qualities. Rye is the common bread-corn in all the sandy districts to the south of the Baltic Sea and the Gulf of Finland, furnishing abundance of food for the numerous inhabitants of places which, without it, must have been little better than sandy and uninhabited deserts. In these districts it not only forms the chief article of consumption, but furnishes a material of some consequence to the export trade of the Prussian ports.

The peasantry in Sweden subsist very generally upon rye cakes, which they bake only twice in the course of the year; and which, during most part of the time, are consequently as hard as a board. Linnæus observed a curious practice in Lapland. One part of rye and two parts of barley being mixed together, the seed is committed to the ground as soon as the earth is capable of tillage in the spring. The barley shoots up vigorously, ripens its ears, and is reaped; while the rye merely goes into leaf without shooting up any stem, its growth being retarded by the barley, which may be said to smother it. After the barley is reaped, the rye advances in growth; and, without any further care of the cultivator, yields an abundant crop in the following year.

Digitized by Google

BARLEY. (*Hordeum.*)

Some writers are of opinion that barley originated in Northern Asia, and do not hesitate to assert that the shores of Samara, in Orenburg, are its primitive home. Other writers, who cite Disdones as authority, indicate its place of nativity in Northern Africa. Certain it is, that at a very early period it was used as an article of food by the Egyptians and Arabians, as well as those occupying Palestine. Col. Chesney, on his return from the Euphrates to England, took with him several kinds of wild barley, as well as some from the ruins of Persepolis. These specimens were of the two-rowed kind—which is the only kind ever observed in a wild state; the four and six-rowed varieties being the result of domestication. The assertion the barley grew wild on the Island of Sicily appears to be unfounded; but no doubt the *Ægilops ovata*, to which full reference will be made in the next chapter, and which is found in great abundance on the shores and islands of the Mediterranean, has been mistaken for wild barley. All accounts with respect to the origin of barley must be received with a considerable degree of allowance, because the hardiest varieties have never been known to propagate themselves for two successive years without the direct agency of man. The seeds of cultivated barley, when adventitiously sown, produce plants truly; but these plants very rarely, if ever, produce seed which will germinate. Botanists have placed some grasses in the same genus with barley, which somewhat resemble the latter in many respects; but, notwithstanding the highest degree of culture yet bestowed upon them, they can not be brought into use as daily food for mankind, nor be made to exhibit any marked degree of improvement.

Barley has a greater geographical range than any other cereal in general use; it is susceptible of being cultivated not only in the central portions of Africa and Asia, but yields good harvests on the Orkney, Shetland, and Faroe Islands, in latitude ranging from 61° to 62¼° N. It does not, however,

Digitized by Google

ripen in Iceland, 63½° N. latitude, but in Lapland its northern limit is near the parallel of 70.°

There are, altogether, perhaps thirty varieties and sub-varieties of barley in cultivation in Europe and America.

In one respect, barley is of more importance to mankind than wheat, from the fact that it is susceptible of withstanding the effects of heat and drought better, growing upon lighter soils, and coming so quickly to maturity, that the short Northern summers, which do not admit of the ripening of wheat, are yet of long enough duration for the perfection of barley. It is the latest sown and the earliest reaped of all the summer grains. In warm climates, such as Spain, the farmers can gather two harvests of barley within the year, one in the spring from winter-sown grain, and the other in autumn from that sown in summer. Barley sown in June is commonly ready for the sickle in three months from the time of the seed being committed to the ground; and in very Northern climates, the period necessary for its growth and perfection is said to be of still shorter duration. Linnæus relates, in his tour in Lulean Lapland, that on the 28th of July, he observed the commencement of the barley harvest, and although the seed was sown only a few days before midsummer, that the grain was perfectly ripe, the whole process having thus occupied certainly not longer than six weeks. The property of not requiring moisture admirably fits barley for propagation in those Northern countries, where the duration of summer is limited to a very few months in a year, and where wet is of very rare occurrence from the time when the spring rains are over, at the end of May or beginning of June; after which period the seed-time commences, till the autumnal equinoxes, previous to which the harvest is reaped.

Oats. (*Avena.*)

The native country of the oat is entirely unknown, but from its hardiness it is supposed to be of Northern origin. It can be successfully cultivated, even to the arctic zone. In Scot-

Digitized by Google

land it is cultivated north of 58½° North latitude, or, in other words, in a parallel of latitude nearly 1,200 miles north of Columbus, Ohio. But after the most diligent search, botanists assure us that no trace of it has been found in a wild state. Some suppose it to be a domesticated variety of some wild species, and Prof. Lindley indicates that the wild species referred to may be the *Avena Strigosa*, or the bristle pointed oat, which, he says, would become the common oat by a slight alteration of the form and divisions of its palæ, and the loss of one of its awns—changes much less considerable than are known to have taken place in other cultivated plants. Its place of nativity has been variously ascribed, as to Persia, the banks of the Euphrates, etc.

Oatmeal, prepared by various processes of working, composes at this day a large proportion of the food of the inhabitants of Scotland, and particularly of the better fed portion of the laboring classes. Oaten cakes, too, are much used in Lancashire.

The wild oat, which is certainly indigenous to this country, is found to be a very troublesome weed. It is said that the seed will remain buried under the soil during a century or more, without losing its vegetating power; and that ground which has been broken up, after remaining in grass from time immemorial, has produced the wild oat abundantly. The Anglo-Saxon monks of the abbey of St. Edmund, in the eighth century, ate barley bread, because the income of the establishment would not admit of their feeding twice or thrice a day on wheaten bread. The English laborers of the Southern and midland counties, in the latter part of the eighteenth century, refused to eat bread made of one-third wheat, one-third rye, and one-third barley, saying, that "they had lost their rye-teeth." It would be a curious and not unprofitable inquiry, to trace the progress of the national taste in this particular. It would show that whatever privations the English laborer may now endure, and whatever he has endured for many generations, he has succeeded in rendering the dearest kind of

Digitized by Google

vegetable food the general food of the country; this single circumstance is a security to him against those sufferings from actual famine, which were familiar to his forefathers, and which are still objects of continual apprehension in those countries where the laborers live upon the cheapest substances. Wages can not be depressed in such a manner as to deprive the laborer, for any length of time, of the power of maintaining himself upon the kind of food which habit has made necessary to him; and as the ordinary food of the English laborers is not the very cheapest that can be readily obtained, it is in his power to have recourse for a while to less expensive articles of subsistence, should any temporary scarcity of food, or want of employment, deprive him of his usual fare—an advantage not possessed by his Irish fellow-subjects, to whom the failure of a potato crop is a matter not of discomfort merely, but of absolute starvation.

The common oat, *Avena Sativa*, is that which is most generally cultivated. One writer (John Haxton, of Fifeshire) enumerates thirty-four varieties of white oats of the *sativa* species, and six black, dun, red, or parti-colored of the same species. Altogether he enumerates fifty varieties of oats.

The *Tartarian* oat is by some considered a distinct species, but it is doubtful whether it can be regarded as any thing more than a variety of *A. Sativa*. Botanists call it *A. Orientalis;* but its native country seems as uncertain as that of the last.

A. Nuda, or naked oat, so called because its grain is loose in the husk, is found wild in many parts of Europe, and by some is thought to be a mere degeneration of the common oat. It is common in Austria, where it is cultivated for its grain, which is, however, small, and not much esteemed.

A. Chinensis, or Chinese oat, is another species, the grain of which is loose in the husk. It is said to have been procured by the Russians from the north of China along with their tea. This species is the most productive of all the kinds known, every flower producing from three to five grains,

Digitized by Google

which are large and of excellent quality. It is, however, said to be difficult to harvest on account of the grains not adhering to the husks, but being very easily shaken out.

Animal Oats.—Besides the species cultivated for the corn which they yield, there is another that deserves to be noticed on account of its remarkable hygrometrical action. This plant, the Animal Oat of gardeners, the A. Sterilis of systematic writers, is something like the common oat when young; but when ripe, its grains are inclosed in hard, hairy, brown husks, from the back of which rises a stout, bent and twisted awn. Usually, two such husks grow together, and separate from the stalk by a deep oblique scar. Taking the scar for the head of an insect, the husks with their long, stiff, brown hairs resemble its body, and the two bent awns represent its legs.

In this State fishermen use a smaller, but nearly allied species, called heavers (*A. Fatua*), instead of artificial flies, for catching trout. When the animal oat is ripe it falls out of its glumes, and in warm, dry weather may be seen rolling and turning about on its long, ungainly legs, as they twist up in consequence of their hygrometrical quality. It necessarily advances as it turns over, because the long stiff hairs upon its body catch against every little projecting point on the surface of the soil, and prevent its retreat.

Nothing can be more curious than to see the path of a garden-walk covered with these things, tumbling and sprawling about in different directions, till their awns are so twisted that they can twist no further. They then remain quiet till the dews fall, or they are moistened by a shower, when they rapidly untwist, and run about with renewed activity, as if anxious to get out of the wet.

Corn. (*Zea Mays.*)

Botanists have, by general consent, applied the generic term *zea* to our Indian corn, no doubt presuming that it was either identical with the Greek zeia, or that it was a species of that

Digitized by Google

genus; but the Greek plant was a species of wheat or barley, and not at all agreeing with the present genus, which is entirely American.

Some writers assert that there is one species only*; others, that there are two†; others again describe three. The common maize is a native of North America, and was cultivated by Indians when the continent was first discovered; it is also cultivated in most countries of Southern Europe. Like the species of Triticum, or wheat, those of this genus present almost innumerable varieties from the cultivation to which they have been submitted. It is found growing wild in many of the West Indian islands, as well as in the central parts of America.

Zea Curagua, or Chili corn, or Valparaiso corn, is distinguished by its serrated leaves. It is smaller in all its parts than the other species, and is a native of Chili. A sort of religious reputation is attached to this plant on account of the grains, when roasted, splitting into the form of a cross.

A chapter or two will be devoted to this cereal in the course of this volume, in which the varieties, culture, chemical composition, etc., will be fully discussed.

Some writers, with great reluctance, admit that the Indian corn was first discovered in America; it will not, therefore, be irrelevant to give in this place a brief history of its introduction into Europe. One fact, which really amounts to strong presumptive evidence of its American origin is this, that previous to the discovery of America it was unknown in Europe. The Spaniards were the first to introduce it on the continent, and the first published account of it was by OVIEDO in 1525. In his description he states that he saw it growing in fields in Andalusia. It was cultivated in very few localities during the reign of Philip II. (1555 to 1598). It is

* Rhind. † English Cyclopedia.

Digitized by Google

stated that the Spaniards introduced it into Sicily in 1560, and hence it was called Spanish, Sicilian, or Turkish corn. At the close of the sixteenth century, it was extensively cultivated in Italy. According to Leonard Fuchs, it was introduced into Germany in 1545, from Greece or Asia, but was cultivated as a curiosity in gardens. It appears to have been known in Hungary as early as the first half of the sixteenth century; from thence it was taken to Russia, and in the seventeenth century into Styria.

RICE. (*Oryza.*)

The true rice plant (*Oryza Sativa*) is confined to warm and marshy districts; hence it is never found cultivated in high latitudes. There are two varieties—the one just referred to, and another called in India the hill or mountain rice. The latter has frequently been introduced into England and France, but its cultivation has never been successful; and Prof. Lindley doubts whether some of the crops reported to have been grown in Europe were *rice* at all. M. Vilmorin, a celebrated French agriculturist and horticulturist, asserts that when he asked for evidence concerning crops of mountain rice, he has uniformly received the *Petty Spelt*, or *Triticum Monococcum*. The *O. Sativa* is cultivated to a considerable extent in Lombardy, and some other Italian states.

In Venezuela and Brazil, it is cultivated to a considerable extent. One variety, the *O. Sativa*, was the only variety that was cultivated during a period of many years; but A. von Humboldt discovered another species in New Granada, which is called by the natives Arozilla, but which is described by Desveaux as *O. Latifolia*. Martins found rice growing wild in the interior of Rio Negro as well as in Paro, in South America. This circumstance indicates that it is a native of both hemispheres, although the culture of it was introduced into North America by the Europeans. Some time previous

Digitized by Google

to the year 1701, a brigantine from the island of Madagascar, happened to put in at Carolina, having a little seed rice left, which the captain gave to a gentleman of the name of Woodward. From part of this he obtained a very good crop, but was ignorant for some years how to clean it. It was soon dispersed over the province, and by frequent experiments and observations they found out ways of producing and manufacturing it to so great perfection, that it is thought to exceed any other in value. Some time afterward, a Mr. Dubois, of the East India Company, sent to that country a small bag of seed rice; from these two introductions it is possible that the two sorts, the red and the white, had their origin in this country.

It is chiefly cultivated in Carolina and Louisiana, and some others of the Southern States. The extent to which it is cultivated in the United States is exhibited in the fact, that in the year 1850, the quantity exported amounted to $2,631,557; in 1854 the exports amounted to $2,634,127.

In the genus *Oryza* botanists have placed numerous plants, some of which are mere grasses in the common acceptation of that term. The *O. Sativa*, or the rice of commerce, is still found in a wild state in and about the borders of lakes in the Rajahmundry circars of Hindostan, though never cultivated, because the produce is said to be small compared with that of the varieties in cultivation. In 1796, Dr. Buchanan found the *O. Coarctata* growing indigenously in the Delta of the Ganges, but was not found to be applicable to any useful purpose.

As an item of interest to agriculturists, it may not be irrelevant to give a short, brief description of the culture of rice. In Carolina and Georgia, a low swamp is selected which may readily be irrigated or overflowed. The swamp has earthen embankments so as to retain the water as long as may be necessary, and has also sluice ways, drains and canals, for the purpose of expelling the water when necessary. Considerable

Digitized by Google

diversity prevails in the mode of cultivating the rice crop. Some planters plow all the grounds every year; those who follow this system give a light furrow in the beginning of January, and afterward make shallow furrows or drills, fifteen inches apart, to receive the seed, which is sown broadcast in April; two to three bushels of seed are used per acre. A small quantity of water is then admitted for a day or two till the grain sprouts. But the most approved and general mode of cultivation is, when the fields are free from weeds to sow without plowing. A negro makes a rut with a hoe between the rice rows of a former crop, although sometimes a small drill plow is used. Either of these methods produce a receptacle for the seed, which is either covered with a rake, or the water is admitted at once and covers it by washing down the soil. In all cases the water is admitted on the field as soon as the seed is sown; and when the young shoot appears above ground, it is drawn off. In the course of a week the crop receives another watering, which lasts from ten to thirty days, according to circumstances. This watering is chiefly used for the purpose of killing land weeds that make their appearance as soon as the ground becomes dry. On the other hand, when the field is under water, aquatic weeds grow up rapidly, and to check their growth the field is once more laid dry, and the crop is then twice hand-hoed. By the first of July the rice is well advanced, and water is again admitted and allowed to remain on the fields till the crop is ripe. This usually takes place from the 1st to the 10th of September. The water is drawn off the day previous to the commencement of reaping. The rice is cut by the sickle, and the stubble is left from a foot to a foot and a half in length, according to the rankness of the crop. The average produce of the unhusked rice is estimated from forty-five to fifty-five bushels per acre; yet from seventy to eighty bushels are sometimes obtained from old fields.

The rice plant adapts itself in a most wonderful manner to the most opposite conditions in respect to moisture; in this

Digitized by Google

respect there is no cultivated plant that bears any resemblance to it. The *same* variety which grows on the upland cotton soils and on the dry pine barrens, grows in the tide swamps, where the land is laid under water for weeks at a time; and even in the lower part of the delta of the Mississippi, where the fields are under water from the time of sowing to that of reaping.

Digitized by Google

CHAPTER III.

HISTORY OF THE WHEAT PLANT.

THE wheat plant is at least co-extensive with civilization, and its fruit beyond a doubt, was used as food by the human race for ages anterior to any historical records. So far back into the dark vistas of time, as authentic history consents to be our guide, do we find that wheat has been cultivated, and aside from animal food, formed the chief alimentary article of all civilized nations; but as the wheat plant has no where been found wild, or in a state of nature, the inference has been drawn by men of unquestionable scientific attainment, that the original plant from which wheat has been derived, was either totally annihilated, or else cultivation has wrought so great a change that the original is by no means obvious, or manifest to botanists.

There are many circumstances, both in history and in science, more especially in botany, which indicate that we are indebted to Persia for the wheat plant, because it is yet found springing up in spots not only at very great distances from human habitations, but out of the usual routes of traffic employed by the natives. It is a well known fact that wheat does not reproduce spontaneously in any place where the grain is cultivated. According to a rule adopted both by Robt. Brown, and Baron Humboldt, to determine the native country of a cultivated species, when that country is unknown, it is within proper bounds to regard that as the probable place of nativity where the greatest number of known species, belonging to the same genus are found indigenous. This rule would indicate Persia, as well as some portions of India, as the place of nativity. "Isis and Osiris discovered wheat, barley and the vine, wild in the valley of the Jordan, and transported them into Egypt, and taught the culture of them.

Digitized by Google

It was at Nysa, also that Isis discovered wheat and barley previously, growing wild in a country among other plants unknown to man."* Strabo, whose writings are, perhaps, the most precise of any of antiquity, asserts that wheat was found growing spontaneously in the Persian province of Mazenderan,† and in the country of the Musicans, to the north of India, as well as on the banks of the Indus.

Some writers, whose opinions are entitled to the greatest respect, assert very confidently, that to India, and not to Persia, are we indebted for the wheat plant; modern botanists, however, know so little comparatively, of the region of India indicated, as to be unable either to corroborate or successfully controvert the statement. There is no doubt that the genus *Triticum* is sufficiently spread over the whole of Asia, as to render Strabo's statement highly probable, according to the rule adopted by Humboldt in such cases, which has just been cited.

In a paper addressed by Sir Joseph Banks to the Horticultural Society, in the year 1805, he speaks of having received some packets of seeds from a lady, among them was one labeled "Hill Wheat," the grains of which were hardly larger than those of our wild grasses, but which, when viewed through a magnifying glass or lens, were found exactly to resemble wheat. He sowed these grains in his garden and was much surprised, on obtaining as their produce, a good crop of spring wheat, the grains of which were of the ordinary size. Every inquiry that was made to ascertain the history of these seeds proved fruitless; all that could be established with regard to the place of their production, was that they came from India, but as to the particular locality, or the amount of cultivation they had received, or whether the grain was indeed in that instance a spontaneous offering of nature could not be ascertained.

The explorations of modern travelers conducted as they are

*Diod. Sic. *l* 1 *c* 14 and 27.

†Michaud found *Triticum Spelta* growing wild on a mountain four days' travel distant from Hamadan, in Persia.

Digitized by Google

with much more system, as well as with most of the advantages which science in its present state can confer, are of greater importance, than those of by-gone centuries, and have in consequence, brought to light many important facts, which, for ages, were among the things unrecorded by previous generations, and unknown to the present, relative to the state of perfection to which many of the sciences and arts had been brought by the Egyptians and other Eastern nations. In the sarcophagi of many of the Egyptian kings or nobles, were found in vessels perfectly closed, good specimens of common wheat, so perfect indeed that not only the form, but even the color was not impaired, although it must have been inclosed many thousands of years. It is well known to every one conversant with the history of Egypt, that the culture of wheat there has long since been abandoned, and no wild plant in any respect resembling the wheat plant is found, but from engravings on ancient tombs at Thebes of the details of plowing, sowing, harvesting and garnering this grain, there is no good reason to suppose it has not been cultivated in Egypt from the earliest dawn of this nation's civilization. After wheat was grown in Egypt, it would readily find its way into Persia, and *vice versa*, and might have been cultivated for centuries and then abandoned, while in some secluded spots it has continued to reproduce itself unaided by human intervention, and thus we find it growing there spontaneously at the present day. But this circumstance alone does not prove that wheat is indigenous either in Persia or Egypt.

It has been claimed that wheat is indigenous on the island of Sicily, and that from here it spread along the northern shores of the Mediterranean into Asia Minor and Egypt, and as communities advanced it was cultivated not only to a greater extent, but with greater success.

The Goddess of agriculture, more especially of *grains*, who by the Greeks was called *Demeter* and by the Romans *Ceres*, was said to have her native place at Enna, which was situated in a fertile region of Sicily, thus indicating the source from

Digitized by Google

which the Greeks and Romans derived their Ceralia. Homer mentions wheat and spelt as bread—also corn and barley, and describes his heroes as using them for fodder for their horses, as the people in the south of Europe do at present. Rye was introduced into Greece from Thrace, or by way of Thrace, in the time of Galen.

In Cæsar's time the Romans grew a species of wheat which was enveloped in a husk, similar to our barley, and which was by them called "*Far*," and appears to have been best adapted to moist and low lands, while the true wheat was grown on the dry or uplands.

During the process of excavation in Herculaneum and Pompeii, were found in numerous places charred grains of genuine wheat.

'Hon. Anson Dart, Superintendent of Indian Affairs in Oregon, states that he found wheat and flax growing spontaneously in the Yackemas country in Upper Oregon, about eighty miles north of the Columbia river; he found it in patches varying in size from a few rods to an acre or more. The straw and head he found to be generally very large, and the berry unusually so; the berry is very plump, and weighs from 65 to 70 pounds per bushel. There is no doubt that both the wheat and flax were introduced at a very early period into Oregon by the Hudson's Bay, or other Fur Companies.

Dr. Boyle, of Columbus, Ohio, informed the writer that when in California he found wheat growing spontaneously in the Carson Valley. He is confident that the wheat he found there growing had no attention from the hand of man, because the grain was not so well developed as the cultivated grain—because for miles it was scattered in "patches" too thin to have been the work of any one attempting the cultivation of the plant.*

*Statement of Dr. Boyle.—Mr. Klippart:—At your request, I will give you a short description of a few plants observed by me on my route to California, overland.

1st. In the valley of Carson's river, just east of the Sierra Nevada, we

Digitized by Google

When the Spaniards visited Mexico, in the sixteenth century, the cereal grasses proper were in cultivation among the Mexicans. In 1530 one of Cortez's slaves found several wheat grains, which had accidentally been mixed with some rice. The careful negro planted these few seeds and their produce for several successive years, and from this small commencement have sprung all the subsequent wheat crops of Mexico, and most undoubtedly to this source may be traced that growing spontaneously in Carson Valley.

Turn to whatever quarter of the globe we may, we find that wherever the foot of civilization has trod, the wheat plant

---

passed through large fields of what seemed to be common beardless wheat, just ripe for the harvest, but upon examining this wheat carefully, I could not find any thing but a very shriveled berry, smaller in diameter than a wheat berry, but in other respects very similar to the poorest berry screened from the wheat in our mills.

2d. In many places I saw specimens of oats, ripe and full, which I could not distinguish from the better varieties of our common cultivated oats.

3d. I found flax in blossom resembling, in all essential particulars, our cultivated flax, but not quite so high.

4th. In California I found frequently a plant like a diminutive bearded wheat stalk, but covered by a downy or woolly cuticle, while the wheat stalk is smooth, or nearly so. This plant presented several varieties, all diminutive when compared to wheat, not being more than ten or twelve inches high, but having a better developed berry than the wheat-like plant of the other or eastern side of the Sierra Nevada, and these diminutive plants I have since thought to be species of Ægilops. And my opinion always has been, that by cultivation, they might be brought to such perfection as to supply the place of, if they did not prove to be wheat.

Besides these mentioned, I observed many other plants, either just like our common cultivated plants, or like these would be if left to chance for propagation, and become degenerated; and the idea presented itself to my mind, that most probably the regions of country in which these were found, now almost without an inhabitant, had formerly been inhabited, and that these various plants had been left to themselves by the removal or extirpation of a former agricultural people, and had in the lapse of ages, become degenerated for want of man's fostering care.

C. E. BOYLE.

Digitized by Google

has monument-like perpetuated the memory of the event; but nowhere do we find the plant growing "*wild.*"

One class of theorists assert that the character of any plant can not be permanently changed by the agency of man, and insist that it is a matter of notoriety that young plants inherit even the most trifling peculiarities of their parents. There is no doubt that the *varieties* in cultivated crops owe their existence chiefly to this physiological law. The HUNTER'S wheat of which so many thousands of acres are now cultivated in Scotland, have all sprung from one single plant found accidentally by him years ago, and all of it that has since been grown has exactly resembled its first parent. So also the Lambert wheat and other varieties in this State. In like manner the valuable Potato OAT had its origin in one oat plant found in a potato field; and to this day the variety is distinguished by the long straw, the large spikes and the early maturity of its ancestor. The Turnip, the Cabbage, the Cauliflower, the Broccoli, the Kail and others are all descended from different accidental varieties of the *Brassica oleracea*, and each variety keeps up in our gardens its peculiarities, thus establishing the hereditary transmission of qualities in plants. There are however many exceptions to this rule, at least to a certain extent. If we take the finest pippin and plant its seeds, we are almost certain to raise the wild crab-apple tree; all the broccolis, cauliflowers, turnips, etc., if left for a time to a state of nature, sow seeds which produce the insignificant wild sea-kail; and as for wheat, if not cultivated it ceases to exist; hence these theorists further assert that in cases wherein changes have been produced, except the exciting cause of the change be unremitted in its application, that the plant would degenerate and revert to the original type, and indicate the "*volunteer rice*" as an example. Lest the reader may not understand the term *volunteer* in this case I will endeavor to explain it: The rice seed that are shed when the crop is cut, and lie over the winter, produce an inferior quality of grain, for under these conditions they appear to revert to their original

Digitized by Google

or natural state. Notwithstanding the husk of the volunteer rice is of the same light yellow color as that of the finest quality, the kernel is *red*. This class of theorists advocate the permanency of species in nature. Hence it is by no means surprising that they should insist that wheat is a permanent species, and point for corroboration of their position to the fact that wherever it has been found growing spontaneously that it preserves all the characteristics of the cultivated varieties.

The opposing class of theorists assert that it is a well established fact that from a veritable pigmy—a small plant with scanty leaves, weighing altogether scarcely half an ounce, has been produced the monstrous cabbage; a diminutive little root growing wild in Chili has been metamorphosed into the inestimable potato; the sweet, juicy Altringham carrot, weighing from five to six pounds, is, in a wild condition, a dry, slender root, unfit to eat; the delicate, well flavored Vienna Glass Cauli Rapi, as large as a man's fist, is, when wild, a slender, woody, dry stem; the cauliflower in its natural locality is a thin branched flowering stem, with little green, bitter flower-buds; that the luscious peach has been derived from the hard shelled almond can no longer be successfully denied; and that the small black sloe has been transformed into the juicy and golden yellow Gage is equally indisputable. The most delicious Spitzenbergs and Pippins owe their origin to the diminutive, acrid crab-apple.

Professor Henslow's experiments rather confirm the doctrine held by the advocates of the "*progressive development*" theory, or rather those who hold that species are not immutable, but are susceptible of being changed and more fully developed by man's agency, climate, soil, and position. In a paper which he read before the British Association, he proved that the Centurea nigra, Black Knapweed, and C. Nigrescens, Dark Knapweed, could be so cultivated as to pass completely into one another. He cited instances also proving that the species of Rosa, Primula, Primrose and Angallis Pimpernelle

Digitized by Google

passed completely one into the other; so that instead of three *species*, there should be three *varieties* of ONE species. It is now a demonstrable fact that the garden daisy is none other than the wild or woodland daisy cultivated; although the botanists yet retain the specific terms of *Bellis perennis* and *B. sylvestris*, as though there really were (as was formerly supposed) two species. Future botanists will in all probability demonstrate that raspberries, blackberries and dewberries are after all not three distinct species, but merely three varieties of one and the same species.

If, then, such astonishing results, as the changes just enumerated certainly are, have been effected through the agency of man, climate, and locality, is there any good reason for supposing that wheat, through cultivation and consequent influences, may not have become so transformed, and yet so permanent and characteristic in its transformation as to render it exceedingly difficult, even to the skillful and accomplished botanist, to distinguish it on the same soil as the legitimate offspring of those plants which formerly grew there spontaneously?

It is not claimed by either party of the theorists alluded to in the foregoing paragraphs, that an onion, by any means now known, can be changed into an apple tree; or that cherries can be grown on currant bushes; but while the one party denies that soil, climate, position or culture, or all these combined, can produce any thing more than temporary alterations in form, the opposing party unhesitatingly declare that soil, climate, position and culture are capable of producing permanent changes, and that the plants so changed have the power of transmitting the acquired characteristics.

VARIETIES OF WHEAT.

There is perhaps no fact connected with the wheat plant better established, than that it, by climate, soil and culture, may be much modified or changed. It would be requiring greater credence than the public are prepared to allow, were

Digitized by Google

we to assert unqualifiedly that red, bearded wheat could be changed into white, smooth wheat; yet incredible as this appears to be, it is nevertheless true. There are instances on record of red wheat being changed into white, and of beardless having been derived from bearded;—these changes or modifications are not sudden, or the freaks of nature, but are the result of the continued influences of surrounding circumstances. The wheat plant is not the only plant whose qualities are affected by climate, soil and culture, neither is the vegetable kingdom alone subject to these influences. While it is an indisputable fact that Europeans have lived for many generations among the Kaffirs and Hottentots, as well as with African tribes nearer the equator, yet hundreds of years have failed to change the delicate carnation on the Circassian's cheek into the ebony of the negro—or to metamorphose the long, straight, dark brown hair into the black wool. The Dutch families who settled in Southern Africa 300 years ago, are now as fair, and as pure in Saxon blood as the native Hollander; the slightest change in structure or color can at once be traced to intermarriage; but Saxon sheep being removed to the torrid zone, in a few generations the fine, soft, compact and valuable fleece is supplanted by a coarse, sparse, shaggy hair; and it is now generally admitted that the original Saxon sheep were exceedingly coarse. In Mexico, the dog and the horse, both, in the course of several generations, become almost hairless, and instead of the hair have a skin not very unlike that of the elephant. In the torrid zone the bee does not lay up a store of honey—it provides sufficient only to feed the new brood.

There is reason to believe that plants, through the influences of soil (their food) and climate undergo as great changes as does the animal kingdom; one of the best established evidences of which is, that cotton grown in a certain district in China is of a nankin color, but when the seeds are brought to America and planted they produce the usual white cotton.

Digitized by Google

It is said that the peach in its original soil was a virulent poison, and that the Persian warriors brought to Persia some of the seeds and planted them for the purpose of poisoning the points of their arrows, so as to render wounds caused by them to be fatal, but a change of climate and soil produced a fruit which is not only luscious, but is esteemed exceedingly healthy.*

It is a tolerably well established fact that continued culture of the same variety of wheat in the same place, will considerably modify or improve its qualities.† The instance related by a gentleman, of red Mediterranean wheat changing into white is not the only one of the kind which has come to my knowledge, but is, perhaps, the best authenticated.

An excellent farmer communicates the following:

"I regard the Mediterranean wheat as earlier than most other varieties, especially when grown on heavy soil. I have known it to ripen more than a week earlier than the red bald or the Canada flint, and think it less liable to the ravages of the weevil. I am aware that it does not yield as greatly as some other varieties, when we are fortunate enough to have them to do well; but as a general thing, I think it by far the safest for a crop. Three-fourths, if not nine-tenths of the wheat raised in this county is the Mediterranean variety. As to its value *now, I view it as quite different from what it was when first grown here.* I have the testimony of our millers as well as my own experience, to sustain me in saying that this wheat yields a greater and better quality of flour than it did ten years ago, in this section at least."

Modifications of this kind, requiring many years to consummate them, may no doubt have been observed by others who have never communicated their observations in such a manner as to find their way into print; while, on the other hand, very

* Transactions of the Russian Economical Society.

† See *Old Red Chaff*—bearded, in list of varieties of wheats.

Digitized by Google

many statements, purporting to be *observations*, have found their way into print much to the *prejudice* of the progress of agricultural science.

There is no doubt that culture, climate and soil, will modify the appearance of plants, to such an extent, in many cases, that the casual observer may be persuaded that an entire metamorphosis has taken place. From hasty observations, equally hasty inferences are generally made, and false conclusions are the result. One of these *pseudo* observations is the supposed transformation of wheat into chess or cheat, or, botanically, *Bromus secalinus*.

The advocates of this supposed metamorphosis claim that excessive moisture, and cold in the spring months, produce the change; another party of supposers claim that pasturing in the spring will cause the change; while a third party claim that hauling with a wagon over the field, after seeding, will change into chess every grain which has been so unfortunate as to have been passed over by any one of the wheels. It requires a greater faith in the susceptibility of species to be transmuted than I ever have been favored with, and requires more evidences than yet have been corroborated by examples in the vegetable kingdom, to induce me to believe that under any conceivable circumstances wheat can be transformed into chess. I will, in as brief a manner as possible, state my reasons for withholding assent to the *cheat* doctrine.

I. Although climate, soil and culture may modify or improve given species of plants or animals, yet it does not change one species into another. The pine of Norway, when removed to Mexico, does *not* become a chestnut, nor the Saxon sheep become a goat, although the character of both pine and sheep are modified; yet when the sheep is returned to Saxony it re-assumes its original characteristics; and although wheat, in all probability, is derived from Ægilops, there is a far greater identity in the general, as well as in the botanical characteristics of both these plants, than there is between wheat and any other plant.

Digitized by Google

II. Cucumbers, melons and pumpkins have more general and botanical characters in common than wheat and chess, yet who has ever claimed that cucumber-seed produced melons, and that these melons in turn produced pumpkins? There is no well authenticated case on record of as complete a transformation of one species into another as is claimed in the case of wheat changing into chess.

III. Like produces like; climate, soil and culture may increase the size, or improve the quality of this product, but generic character can never be changed. The improved short-horn bull of to-day is an animal differing in outline *perhaps* from the "*ring-streaked and speckled*" cattle of antiquity; but he can not be changed into a giraffe, elk, deer, nor horse. There is far greater resemblance between oats and chess, than between wheat and chess. The wheat produces a head or *spike*, chess produces a diffuse and spreading top or *panicle*, as distinct and different from the wheat-spike as is a Morgan horse from a Rocky Mountain goat. There is no well authenticated case on record of any parent producing so unlike a progeny; neither is there any record of so great a transformation having taken place by the most exact conformity to known laws, and the most unremitting care and attention during a century, as is claimed by the wheat-transmutation advocates.

IV. The law, influence, or circumstances, must necessarily affect all within its reach—if it can possibly change a single one, it must operate on all similarly situated to the one changed. In Ohio we have generally about eight inches of rain in April and May; in 1858 we had eight and a quarter inches in the month of May alone, and fully half as much in April; if, then, excessive moisture is the cause of the transmutation, the entire wheat crop of 1858 in Ohio should have been transmuted. But the advocates of the theory may claim that so extensive an application is taking too great a license with their doctrine; we will, therefore, confine ourself to a square foot of ground which is perfectly level, and the soil is

Digitized by Google

of the same quality, as well in mechanical as in chemical composition, as possibly may be found anywhere on a similar area. On this square foot was found wheat and chess growing in the following order:

C.	W.	W.	C.	W.	C.
W.	W.	C.	W.	W.	W.
W.	W.	W.	W.	C.	C.
C.	C.	W.	C.	C.	W.
W.	W.	C.	W.	W.	W.

To be sure they did not grow in such precise regularity as above indicated, but they all grew on the area above mentioned, and in the relative position, as marked by the initials above—C. being Chess and W. Wheat. What law in nature could possibly transmute one-half of the wheat stalks in the upper-line, one-sixth of the second row, one-third of the third, two-thirds of the fourth, and one-third of the fifth, when the topography was precisely the same, the soil the same, the moisture and atmospheric influences precisely the same? *The truth is, no transmutation ever took place; all the chess found in grain fields is the direct product of chess seeds.* This announcement may possibly startle some of those who hold that chess is deaf, or produces husks or chaff only; but they have never examined the flower of the chess, nor submitted the reproductive organs of this plant to microscopic investigation. Chess has as perfect a flower as wheat has, and produces a grain capable of germination, and thus reproduces and perpetuates its species. The husk or chaff of chess is very thick, and protects the albuminous body for several years from decay when it is too deep in the earth.

Every farmer must have observed in spring time, in pasture fields or meadows, where cattle had been during the autumn, that wherever there were droppings from the cattle, the grass appeared to have a thriftier growth, so much so that the number of droppings could be counted as so many green hillocks many rods distant. All the plants, whether clover, timothy,

Digitized by Google

red-top, June or orchard grass, whose seeds or roots came within the influence of the dropping, were affected by it; they all grew larger and greener than the grasses not so affected; but the clover was not converted into timothy or red-top, nor June grass into clover or timothy. Neither does the manure affect the timothy and not other grasses, but affects all alike. Therefore, if any influence operated upon the square foot of soil above referred to, it must have changed *all* the wheat on it into chess, if it possibly could have changed a single grain.

Chess requires considerable moisture to induce it to germinate, hence it is found most abundantly in moist places; here it grows more rankly than wheat does, and in a short time overshadows and chokes the wheat, and the careless observer seeing chess abundant about harvest where wheat plants appeared in the spring, concludes that the one has been transformed into the other.

The thick hull or chaff of the chess protects the albuminous body from the operation of digestion in the craw of birds, or stomachs of horses or cattle. Birds passing over wheat fields may drop chess seeds, and from the droppings of horses and cattle, chess seeds may germinate; hence it is not uncommon to find chess growing about stumps and logs in newly cleared lands.

A late revival of the transmutation controversy induced Benj. Hodge, Esq., of Buffalo, N. Y., to offer a premium of one hundred dollars to any one who should prove that wheat had turned to chess—the premium to be awarded under the supervision of a committee appointed by the N. Y. State Agricultural Society. The premium was claimed by Samuel Davidson of Greece, Monroe Co., New York. The Society appointed a committee of investigation consisting of Prof. Dewey, Rochester, N. Y., Chairman, who reported the following as the result of the examination:

"The experiment to prove the transmutation was the following. A quantity of earth was passed through a fine sieve, to separate all chess seeds. It was placed in a pan and

Digitized by Google

several heads of wheat planted in it. When the wheat came up it was subjected to all the hard treatment that usually produces winter-killing, viz.: flooding with water and alternately freezing and thawing for several times. Late in the spring the whole contents of the pan were removed and set out in the open ground. When the plants of wheat threw out their heads there appeared chess heads also. This mass of wheat and chess plants was brought in and placed before the committee. Stalks of chess were shown, the roots of which were found to proceed directly from the planted heads of wheat which yet remained entire, and in some instances they were found to issue from the half decayed grains of wheat themselves.* This was looked upon as conclusive.

"The roots were taken by the committee and first soaked in water and afterward gently washed, by moving them backward and forward slowly through it. They were then carefully examined by microscope. The roots of the chess were now perceived to issue, not from near the end of the grain of wheat as is usual in sprouting, but from the *side*, and in fact from almost any part. Further examination showed that they merely passed *through* crevices in the decayed wheat grains, and that they were separated from the grains without tearing, being merely in contact, without adhesion or connection. Some of the more minute chess fibers were observed by an achromatic microscope to extend over the inner surface of the bran, where they had gone in search of nourishment (which is known to abound just within the bran) in the same way that grape roots have been observed to spread over the surface of a rich decaying bone. But they easily separated and had no connection with the bone. It was satisfactorily proved that the chess plant could not have come from these grains, by the fact that the

* When the wheat is in head no trace of the original grain can be found—the contents of the wheat grain are entirely consumed by the young plant at the expiration of 30 days from the time of sowing. Prof Dewey is evidently mistaken in the above statement.—KLIPPART.

Digitized by Google

same single stalk of chess was thus connected with five or six different grains which could no more have originated it, than five or six cows could have one calf. The examination therefore did not prove any thing in favor of transmutation, and as there were many possible ways in which the chess might have been scattered on the soil, the whole experiment was admitted by all parties to be inconclusive."

If farmers will habitually sow clean seed, there is little danger that they will be troubled with chess.

There is another fact which it would be well to remember in controversies on subjects of this nature, viz.: all species, and not unfrequently genera which are allied will hybridize, that is, will produce offspring partaking of the nature of both parents, yet not resembling either in every respect; thus the horse and ass are allied species of the *Equine* genus, they hybridize and produce the mule.* Wheat and chess *will not* hybridize, thus proving conclusively that there is neither specific nor generic affiliation existing between them.

Wheat may at different periods have been produced from the Ægilops in various countries; in India, Persia, Egypt, Greece, California, South America, etc., and the different varieties may have been derived from the originals from the various localities having been modified by soil, climate and culture.

Experience teaches that by high culture red wheats change into white ones, and although we have no direct evidence that bearded or awned wheat changes into beardless, yet the French Journal d'Agriculture Pratique, speaks very highly of a bearded wheat which loses all its beards the moment it ripens.

Mr. Daniel has introduced on the farm of Barliere (Haut Loire) a variety of white wheat from Russia, which merits attention. A small sheaf of it was on exhibition at the World's Fair. It is said to be very productive, and to make an excellent quality of second-rate bread, such as is in general use by the agricultural population.

---

* See Chapter I, where hybridization is more fully discussed.

Digitized by Google

The spike or head of the wheat is stout and long, the awns or beards are *very* long, and drop off the very moment that the grain is matured. The chaff is thick and coarse, and protects the grain from many attacks to which the thinner chaffed varieties are subjected. The grain is large, white, and very heavy. It is cultivated by the farmers in the vicinity of Brionde, without extraordinary manuring, or other care, and the harvest generally yields 38 to 44 bushels per acre. It succeeds best in good soil, but is not susceptible of withstanding great extremes of cold, more particularly the cold of humid and insalubrious districts; although it appears not to have been affected by the cold of last December. The straw is long, heavy, and of a remarkable whiteness.

It is by no means improbable that in some localities, the Mediterranean has, since its introduction into the United States, lost the awns or beards, and is now known as the beardless, or smooth, red Mediterranean. In localities where climate and soil more readily affect changes than culture, the smooth, red Mediterranean may have become white. If the same variety of wheat were sent to Canada, Central Ohio, Tennessee, and California, from Norway or Denmark, and the wheat thus sent be cultivated on the same farm for a period of fifty successive years in each of the localities just mentioned, there is no doubt that at the expiration of this period, if a comparison were to be instituted, the varieties would be found to differ greatly from each other, and all differ from the original, not only in appearance, but in quality. And, more than all, while that in Canada ripens there the first of August, that in Tennessee the first of June, that in California the tenth of May, that in Central Ohio will not ripen before the first of July. If, then, imports be made of the identical variety to Ohio from Canada and Tennessee, and sown side by side with that already acclimated in Ohio, it will be found that that from Canada will ripen a few days *earlier*, and that from Tennessee a few days *later* than that of Ohio. Even in the limited extent of latitude embraced between Lake Erie on

Digitized by Google

the North, and the Ohio river on the South, there is an appreciable modification in the same variety of wheat. A spike of Mediterranean grown in Trumbull county differs as much in appearance from a spike of the same variety grown in Lawrence or Scioto, as it does from a spike of "*old red chaff*," or of "*Quaker wheat*."

So well is this fact understood by botanists, that Prof. John Lindley remarked of the wheats on exhibition at the Crystal Palace in 1851:

"I have already said, that among the wheats produced in the Exhibition, that from our South Australian colonies is the best—that it is much the best. And here let me make a remark on that subject. It has been supposed that all we have to do in this country, in order to obtain on our English farms wheat of the same quality as this magnificent Australian corn, is to procure the seed and sow it here. There can not be a greater mistake. The wheat of Australia is no peculiar kind of wheat; it has no peculiar constitutional characteristics by which it may be in any way distinguished from wheat cultivated in this country; it is not essentially different from the fine wheat which Prince Albert sent to the Exhibition, or from others which we grow or sell. Its quality is owing to local conditions, that is to say, to the peculiar temperature, the brilliant light, the soil, and those other circumstances which characterize the climate of South Australia, in which it is produced; and, therefore, there would be no advantage gained by introducing this wheat for the purpose of sowing it here. Its value consists in what it is in South Australia, not in what it would become in England. In reality, the experiment of growing such corn has been tried. I myself obtained it some years since for the purpose of experiment, and the result was a very inferior description of corn, by no means so good as the kinds generally cultivated with us. And Messrs. Heath and Burrows, in a letter which I have received from them this morning, make the same remark. They say, 'For seed purposes it has been found not at all to answer in England,

Digitized by Google

the crop therefrom being ugly, coarse, and bearded.' The truth is, as was just observed, the peculiarities of South Australian wheat are not constitutional, but are derived from climate and soil. It appears, therefore, that wheat may be affected by climate, independently of its constitutional peculiarities; but it does not follow that wheat is not subject to constitutional peculiarities like other plants. There are some kinds of wheat which, do what you may with them, will retain a certain quality, varying but slightly with the circumstances under which they are produced; as, for example, is proved by some samples here, especially of Revitt wheat, of a very fine description, exhibited in the building by Mr. Payne, and which is greatly superior to the ordinary kinds of Revitt that appear at market. This clearly shows that Revitt wheat of a certain kind and quality is better than Revitt wheat of a different kind, both being produced in this country; so that,

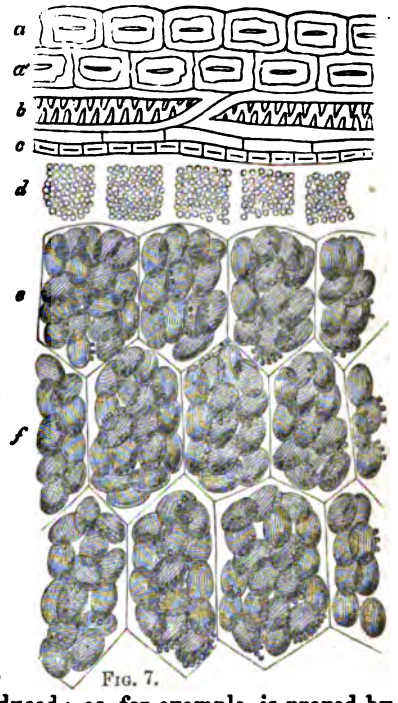


FIG. 7.

Fig. 7. Section of a wheat grain highly magnified.
a. a. cellular layers of the first seed skin.
b. same of the second.
c. the third or innermost skin.
d. cells of gluten.
e. the cellular tissue of the albumen with grains of starch meal.
f. grains of starch.

Digitized by Google

circumstances being equal, we have a different result, owing to some constitutional peculiarity of race."

The principal difference between red and white wheat exists in the amount of gluten and silex, or cortaceous (bran) substances. Gluten (*d.* Fig. 7.) is found to be two or even three times as thick in some varieties, as in others. It is thinnest in white wheat, medium in *amber*, and thickest in coarse, heavy red wheats. The skins (*a. a. b.* Fig. 7) abound in silex to a greater extent in red than in white wheats. But climate, soil and culture, modify the amount of gluten and silex, as well as other characteristics of the plant, and thus produce new varieties.

There are many varieties of wheat now cultivated in this State which owe their origin to some peculiar, and perhaps local influence. There are several cases on record where the same variety has been habitually cultivated on the same farm for many years, when suddenly a strange *head* is found making its appearance in the field. This head not unfrequently is larger and presents other indications of being an excellent, if not superior variety of wheat. Where did it come from? The farmer has not been changing the variety of wheat, and why is there a single head only, or half a dozen heads at most? If there were a square yard or more covered with the new variety, one might suppose that the product of any entire head had been sown, or by some fortuitous circumstance had found its way there. It is idle to suppose that birds of passage might have dropped it in their migration; because, in the first place, it is probable that the germinating qualities would be destroyed at least, if not the entire grain be digested; but because, if birds did convey it there, they must have obtained it somewhere, within a few days' flight of the place where it was dropped, and the variety of wheat would be recognized as coming from the North, South, East or West. Notwithstanding the improbability of new varieties being introduced in the manner just mentioned, the theory is entitled to due consideration. The advocates of this theory assert that the birds

Digitized by Google

which convey the grains, proceed from the North to the South, and bring the grain from the North. The Northern varieties are more hardy than those acclimated here, and not so readily digested by the birds. The birds wing their way to the South at the approach of winter, when deep snows cover the ground and thus hide their accustomed food, in the far North; and the seeds dropped by them on our grain fields germinate before the cold of winter has actually set in.

It is true that any variety of wheat taken South any considerable distance from its accustomed locality, will not only increase in size, but present a more vigorous and hardy appearance than that already acclimated. Hence the plausibility of the "*bird* theory."

Another party of theorists assert that the grain or grains which produce new and superior varieties, have accidentally fallen in places the soil of which is of peculiar chemical combination, or whose mechanical structure differs from the remainder of the soil, upon the same principle that grass growing under the droppings from animals in pasture fields, obtains elements and ingredients if not different in combination from those in the soil generally, yet in much greater proportion; that these incidental peculiarities of soil, produce characteristic changes in the structure and appearance of the plant. The advocates of this theory refer to the experiments of *Salm-Horstmarr*, which are given in another place in this book, as being collateral, if not conclusive evidence, of the correctness of their position.

A third party ascribes the origin of varieties to hybridization. It is very evident that wheat does not naturally hybridize, because if it did "mix" as readily as can corn, *sorghum saccharatum*, or *lolium perenne*, the agriculturist could produce at pleasure, the most desirable varieties in vast quantities in a single year. Were it true that wheat hybridizes in the field without the agency or interference of man, then, to find grains of a dozen different varieties in the same head or spike of wheat, might be regarded as the *rule*, and a head in which

Digitized by Google

the grains were all of the same variety would be the *exception*, yet how often do we find half a dozen varieties of wheat, sowed in the same field and growing side by side for successive years, preserving and perpetuating their characteristics, without the least appreciable change due to hybridization.

It must be obvious that wheat harvested in an unequal state of ripeness, can not be the best for the purpose of making bread, as when the greater part of the grain has been cut in the state the farmer considered fitted for the miller, while the lesser part has been either in a milky state, or much over-ripe, or some in all possible stages of ripeness.

The greatest quantity of flour is not obtained from wheat cut in this manner, but would be obtained when every ear produced that fine, plump, thin-skinned, coffee-like looking germ, and a delicate, transparent, thin-coated bran. Hence it is assumed, that to have the best bread from any variety of wheat, is to have it so pure, that, supposing it to be grown on a level space, with one exposition, it will all ripen at the same time; slight differences being allowed for variation of soil, sub-soil, or accidental unequal distribution of manure; but, that as a general thing, it will ripen equally. I must here observe, that the cause why so much wheat appears to have many shriveled, lean, ill-grown grains in it, arises often from the unequal growth of the many varieties that lurk in the purest crop. No writer has yet, I believe, directed the attention of the agricultural world to the cultivation of the pure sorts, originating from one single grain. It is contended that this has been the root of all evil; many have attempted to begin well, but few, if any, have thought of commencing from the original, and persevering and keeping it pure.

I am well aware that many may consider this project visionary and unattainable. It has been asserted that if even a pure crop were sown, the bees would mix the farina, mice would mix the grains, birds would do the same, and more than all, if it had been feasible, it would have been done long ago.

Digitized by Google

It is of paramount importance to ascertain and keep note of the period of flowering of each variety to be cultivated, on extensive farms, which will tend more to keeping up a pure sort than any other method.

So far as actual experiments in hybridisation with wheat are concerned, I can do no better than to quote from the excellent lecture of Prof. John Lindley, referred to in a preceding page:

"But this leads to a question which I think of the highest interest, and one which has been more distinctly brought out in the exhibition that has just closed than it has ever been before. We all know the EFFECT of HYBRIDIZING, or crossing the races of animals; and we also know that within certain limits, this may be done in the vegetable kingdom. We are all aware that our gardeners are skillful in preparing by such means those different varieties of beautiful flowers and admirable fruits which have become common in all the more civilized parts of Europe; but no one has paid much attention to the point as regards cereal crops. Yet it is to be supposed, that if you can double the size of a turnip, or if you can double the size of a rose, or produce a hardy race of any kind from one that is tender, or the reverse, in the case of ordinary plants, you should be able to produce the same effect when operating on cereal crop. It so happens, however, that the experiment has not been tried except on the most limited scale, and to what extent it may be carried, has been more brought out in this exhibition than it ever was before. In the last treatise on this subject by Dr. Gærtner, a German writer, who has collected all the information it was possible to procure relating to the production of hybrids in the vegetable kingdom, the author declares that, as to experiments on cereal plants, they can hardly be said to have had any existence. The exhibition has, nevertheless, shown us that they have been made, and some examples will tell with what result. I have no very good means here of explaining such experiments, but I must advert to them, because they prove dis-

Digitized by Google

tinctly that you may operate upon the constitutional peculiarities of wheat, just as you may upon those peculiarities in any other plant. For instance, Mr. Raynbird, of Laverstoke, who obtained in 1848 a gold medal from the Highland Society for experiments of the kind, sent to the exhibition this box, which contains a bunch of Hopetown wheat, a white variety, and a bunch of Piper's Thickset wheat, which is red. The latter is coarse, and short-strawed, and liable to mildew, but very productive. Mr. Raynbird desired to know what would be the result of crossing it with the Hopetown wheat, and the result is now before us in the form of four hybrids, obtained from those varieties.

"If you will take the trouble to examine them, you will see that beyond all doubt the new races thus obtained are intermediate between the two parents—the ears are shorter than in the Hopetown, and longer than in the Thickset wheat; in short, there is an intermediate condition plainly perceptible in them throughout. And it appears from the statement of Mr. Raynbird that these hybrid wheats, which are now cultivated in this country, have succeeded to a satisfactory extent, yielding forty bushels an acre. But in this instance, as in some others which I am about to mention, I do not at all attach importance to that circumstance. The essential part of the question is not the number of bushels produced per acre, but to show that you may affect the quality of cereal crops as you may affect animals and other plants. Mr. Maund, a very intelligent gentleman residing at Bromsgrove, in Warwickshire, has done much more than Mr. Raynbird, for he has obtained a greater variety of results, which he exhibits this evening. Mr. Maund has been occupied for some years past in the endeavor to ascertain whether something like an important result can not be produced upon wheat by muling, and he exhibited the specimens before us in evidence of what may be done. You will observe that sometimes his hybrids are apparently very good, and sometimes worse than the parents, as we know is always the case. When you hybridize

Digitized by Google

one plant with another, you can not ascertain beforehand with certainty what the exact result will be; but you take the chance of it, knowing very well that out of a number of plants thus obtained some will be of an improved quality. If you examine this glass case you will at once see the results obtained by Mr. Maund. In each instance the male parent is on the left hand, the female on the right, and the third specimen shows the result of combining the two kinds; a better illustration could not be desired. Here is a hybrid considerably larger than the parents, and in the next instance one considerably shorter and stouter. In another example you see a very coarse variety gained between two apparently fine varieties; that is, perhaps, a case of deterioration. In another instance you have a vigorous wheat on the left, and a feeble one on the right, while one, much more vigorous than either, is the result. On the other hand we have some anomalous cases, in which the effect of hybridizing has been to impair the quality.* Now, I think this is a very important case, well made out, because the moment you show that by mixing corn, as you mix other things, you obtain corresponding results, there is no reason to doubt that an ingenious person, occupying himself with such matters, will arrive at the same improvements in regard to varieties of corn as have already been obtained in the animal kingdom, and in those parts of the vegetable kingdom which have been so dealt with."

The same law of transmission of qualities from parent to offspring appears to obtain in the vegetable, as in the animal kingdom. It is well known to all cattle breeders that the offspring bears a much greater resemblance to the sire than to the dam, while the *disposition* of the dam rather than that of the sire is transmitted. Mr. Maund in his series of experiments in hybridizing found that a strong sire and weak female produced a much better result than a weak sire and strong female. All of No. 8 in the above list were of this latter character.

* See Chapter I., near the close.

Digitized by Google

The new varieties thus artificially produced, usually prove to be of earlier development and maturity, as well as more prolific and better adapted to withstand the extreme vicissitudes of the climate than either parent.

The entire practicability of producing new varieties of wheat at will, being thus demonstrated, we trust it is not indulging in too sanguine expectations when we predict that ere many years the farmers of Ohio will by this method produce the best varieties that the world ever saw.

There is no doubt that the cultivation of Mediterranean wheat would at once be abandoned in Ohio, were there a variety of white wheat which would as successfully resist the various diseases caused by fly, midge, rust, etc., and which would withstand the cold and drought as well. Such a variety can undoubtedly be produced by hybridization; and as an experiment in the proper direction we would suggest that a cross be produced between an early plant of the white blue stem, and an early one of the Genessee flint, or the Quaker wheat. It often happens that the first cross is not what is desired, then a cross between this first hybrid and one of the parent races, or even a second, or some cross of this kind may result in this quality. To demonstrate more fully, suppose a hybrid with Genessee flint as male, and white blue stem as female, is produced, which we will call the Genessee blue stem, but is not desirable, having too much of the characteristics of the original blue stem. Then produce a cross with the same former male upon this hybrid, and name the result hybrid No. 2. Suppose this result to partake yet too much of the blue stem characteristics; produce another hybrid with the same male as in the other cases, but with hybrid No. 2 as female, and name the product hybrid No. 3; this result may now have more of the Genessee qualities than are desirable. Then a hybrid between No. 2 and 3, will perhaps produce the desired qualities.

Sometimes it happens that the varieties from which new varieties are sought to be obtained, will not hybridize with each other; as for example should it prove that the Mediterranean

Digitized by Google

would not cross with Soules wheat, but that a cross from these two varieties would combine desirable qualities. When such a case occurs, the cross must be made with such as will cross with both the Mediterranean and the Soules. The Soules may be crossed upon the Genessee Flint, and this product be called No. 1, or Soules Genessee, then Mediterranean may be crossed upon the Genessee and the product called No. 2, or Mediterranean Genessee; then No. 1 (as male) crossed upon No. 2, (as female) will produce a hybrid which will be one-half Genessee, one-fourth Mediterranean and one-fourth Soules; this will be No. 3. This last hybrid will cross with the original Soules, and produce a variety that will be three-fourths Soules, one-twelfth Mediterranean and one-sixth Genessee; this hybrid will be No. 4. Then No. 3 crossed upon the Mediterranean will produce a variety, being three-fourths Mediterranean, one-twelfth Soules, and one-sixth Genessee; this will be No. 5. Now a cross between the hybrids Nos. 4 and 5, will produce a hybrid being five-twelfths Mediterranean, five-twelfths Soules, and one-sixth Genessee Flint. This No. 5 may be crossed back upon either of the parents, and the consequent hybrids crossed upon each other until all of the Genessee Flint taint is bred out; and then the result will be a hybrid of two varieties which originally would not hybridize with each other.

There is no doubt that these hybrids are constitutionally more susceptible to the influences of heat than the parent varieties, hence their earlier maturity. There is no reasonable doubt that by hybridization many excellent varieties may be produced, which, in Northern Ohio, will ripen in ordinary seasons not later than the 20th of June, and in Southern Ohio, as early as the 10th of June. Were such a variety produced, the ravages of the weevil would be set at defiance, the rust could not injure it, and many inconveniences experienced at present would be avoided.

When the agriculturist deems it advisable to change the varieties of wheat which he has been cultivating, the new varie-

Digitized by Google

ties should be imported from the north. The reason of this is very manifest; the north being colder, requires a longer period of time to mature and ripen the grain than it does here, consequently the new variety when grown here will arrive at a maturity and ripen *earlier* than in the north; whereas in the south a greater degree of warmth obtains and wheat ripens earlier than here; consequently when southern wheats are introduced here, they seldom succeed, or are continued by the cultivator, but most generally after one or two trials, are abandoned. For this reason many of the wheats introduced from Europe, through the Patent Office, do not succeed in Ohio—they are generally found to be too tender for our winters, and more liable to "winter-killing," rather than any other malady. The following, from an esteemed correspondent, is in strict confirmation of the views advanced. The extract will be better understood when it is known that the Isothermal line of Turkey, and all the northern shore of the Mediterranean, is the same as that of Tennessee, Arkansas, etc.:

"In September, 1855, sowed a package or two of Turkish Flint Wheat—mostly winter-killed—harvested a little more than the seed sown—this was sown in September, 1856. It looked well up to the falling of snow; that went off early in February, and every plant was winter-killed, while the Genessee Flint Wheat, sown by the side of it escaped entirely. During the past two seasons, having experimented with five kinds of imported winter wheat, received from the Patent Office, I found none of them comparable with the Genessee Flint. I trust, however, that they have done better further south, as some of the samples were very fine.* There was one variety (from Japan†) with a very red chaff, short chaff, short

* But even if these varieties were acclimated at the south and proved to be excellent varieties, they might not be desirable in Ohio; they certainly would mature and ripen *late*, thus becoming liable to rust, midge, and other maladies incident to the late varieties, as well as being liable to *winter-kill*, and otherwise deteriorate.

† The Isothermal line of Japan is about the same as that of Tennessee.

Digitized by Google

head and straw, that blossoms some ten days earlier than any other kind I have grown, but it has been mostly winter-killed. If it were hardy and productive (and may it prove so further south) it would be an invaluable variety for cultivation in those sections of country where the midge prevails—from its earliness it would escape their ravages."

All the varieties imported from Europe which have become *standard* in Ohio, were brought from high latitudes. The most popular wheat at present in Ohio, is the Mediterranean, so called, which is of Danish or Norwegian origin, from whence it was introduced into Holland, and from the latter kingdom into the United States, under the name of "*German Wheat:*" in a short time it was known as the *German Fly-proof Wheat*,* then by the singular but indefinite cognomen of "*Fly-proof Wheat*," and lastly, it is now extensively known as the Mediterranean variety. The following, from one of the "old" volumes of the American Agriculturist, furnishes the history of its introduction into the United States:

"Several years ago (about 1819), an American gentleman who was traveling in Holland, while one day dining with a number of Hessians, was asked why, with our fine climate and soil, we had so often failed in having good wheat crops? He replied that it was doubtless in a great measure attributable to an insect which it was supposed was introduced into the United States in the wheat sent from Holland during the Revolutionary War, for the subsistence of the British army, which was known in this country as the Hessian Fly. The Hessians admitted that some kinds of wheat in that country were liable to injury by insects, but that there was a species in very general use that resisted their attacks. The American gentleman was presented with some of this, which he brought to this country and sowed upon his farm in Delaware. It

* *Fly-Proof* or *German Wheat.*—A gentleman who was supplied by us with a part of the lot received from Virginia, informs us that there has been a great improvement in the appearance of the grain since its introduction on his farm.—*American Agriculturist.*

Digitized by Google

was subsequently introduced into Virginia by James H. Taliaferro, Esq., and its ability to resist the attacks of the fly successfully tested. The name Mediterranean, given to this wheat has no applicability whatever." *

The agriculturist will be disappointed in the best variety of wheat, if the crops are not kept pure. Not unfrequently is there grown in the same field white and red, as well as smooth and bearded, side by side. Early and late varieties are mixed together, and while one is "*dead ripe*" and is shedding its grains, another variety which occupies perhaps an equally large area, is just in the "*milky*" state. It is very manifest that the flour from this mixture can not possibly be as desirable as that of either variety when pure, and harvested at the proper season.

As there are so many varieties of wheat of similar external appearance as even to baffle the most experienced eye, there seems to be but one secure method to insure the growth of pure sorts of wheat, namely, to grow them from single grains, or from single ears, and to follow up the plan, by afterward sowing only the produce of the most productive, so as to form a stock. A curious but satisfactory proof, which repeated experiments have confirmed, is that the grains of wheat when sown thickly, impart a certain degree of warmth to each other and to the soil, which hastens their growth two or three days earlier than a single grain.

A knowledge of the precise moment of flowering may prove of

---

* Several years since, Mr. M. B. Bateham, of Columbus, Ohio, introduced several of the choicest varieties of wheat from England, but none of them succeeded, because the change in climate was entirely too great; the change in the actual amount of heat could, perhaps, have been withstood, had there been no diminution in moisture, but our climate is dry as well as hot, while that of England is cool and moist. If these varieties had been taken to Canada, where the climate is dry and cool, and the temperature the same as in England, there is no doubt that they would readily acclimate, and then, when acclimated, if transferred to the United States, would perhaps prove a desirable acquisition.

Digitized by Google

the greatest importance to an intelligent farmer, there being an interval of a week or ten days in the period of flowering of some of the sorts. Hence, a judicious selection, with due care as to the time of sowing the variety that will soonest come into flower, would enable him not only to keep his crops pure, but as they would ripen in succession, enable him also to bring in his crops in rotation, as each variety ripens, without being hurried by his whole crop being fit for harvesting at the same moment, which is now too often the case.

A single grain picked up on the high road by chance, and perceived to be of an entirely different form and larger in size than is generally seen, though sown a week later than the other varieties, was the first to ripen and was cut a week earlier than other varieties.

"Two years ago," writes John Le Couteur, "a farmer requested me to view a *very pure* crop; there was no mixture in it! In merely walking round the crop, which, in fact, was both pure and fine, in common parlance, I selected from it ten varieties." A crop of this variety, the Duck's Bill, then originally procured from Kiel in the Baltic, which I saw this year as a second year's produce, is so intermixed as to make it difficult to pronounce what variety it is intended for. The Duck's Bill is very subject to shake out from the ear if it is over ripe; and has proved to be only fit for making pastry, as it is too tenacious for the purpose of making household bread; hence the necessity of not only having wheat crops pure, but of knowing their particular qualities and properties.

It is very extraordinary that some sub-varieties have a predisposition to sport, or alter their appearance.* A fine red

* The following detail is copied from Le Couteur's work on the wheat plant:

But it had escaped him to consider it in its properties, with relation to the food of man. This practical view the author took of it, and he determined to attempt to discover which were the most farinaceous and productive varieties, by comparing their characters and produce one with another. The usual mode with the generality of farmers is to procure any seed, that any neighbor, enjoying the reputation of being a good

Digitized by Google

sort was sown with others, pure apparently, and of three hundred and fifty ears, the produce of forty-six grains, there were

---

farmer, may have to sell. A more intelligent class take care to procure their seeds from a distance, to require that it is fine, perhaps even pure; they also have thought of changing or renewing their seed occasionally. A still more intelligent number having procured the best seed they could obtain, of those sorts which observation and experience, have led them to know as being best suited to their soil and climate; having further observed, that mixtures in their crops prevented their ripening at the same moment, and having endeavored to remedy this defect, by making selections by hand, of those varieties which appeared to them to be similar and thus have greatly improved their crops in produce and quality. A few farmers have proceeded a step further, and from having observed a stray ear of apparently unusually prolific habits, have judiciously set it apart, and have raised a stock from it. Hence the Hedge Wheat, Hunter's, Hickling's and twenty more that might be named; but it is contended that it is not sufficient merely to have grown them pure for a short time; it is necessary to keep them permanently so, if after a comparative examination as to their relative product in grain and meal, they shall be proved to be the best; or otherwise to discard them for more valuable varieties.

This was the chief consideration which led me to make comparative experiments in order to obtain the best seed. Hence, as a first step toward improvement, Professor LaGasca having shown me four ears of those he considered the most productive, I sorted as many as I could collect, of precisely the same varieties, judging by their external appearance. Such was my anxiety to attempt to raise a pure crop, that in the month of November, 1852, I rubbed the grains from each ear, of all the four sorts I had selected, throwing aside the damaged or ill-looking, and reserving only the plump and healthy.

The first selection was apparently one wholly of a Dantzic sort—white and smooth eared. In the process of rubbing, I was surprised to find that, though most of the grains were white, they differed greatly as to form, some being round, some oval and peaked, some plump but very small, some more elongated, some with the skin or bran much thicker than others. There were also many with liver-colored, yellow, and dark grains, among the white.

The second sort was from a square, compact variety of wheat, the grains very plump, round, of a coffee-like form, very thin-skinned and white. There was a pale red inferiority among it, much thicker skinned, but without any perceptible external appearance in the ear.

Digitized by Google

two hundred to the original sort, which were a red, compact, hoary or velvety kind, twenty-one ears of a smooth red, eighty-six of a whitish, downy appearance, and forty-three smooth-chaffed white ears.

The third was a downy or hairy variety, one of the "Velovtes" of the French, and "Triticum Cœleri" of Professor LaGasca; a velvety or hoary sort, which is supposed to be very permanent in its duration, as relates to keeping pure. I found, however, that there were a few red grains, some yellow, and some liver-colored sorts among this, in small proportions it is true, but being of prolific habits, subsequent experience has taught, that they would soon have destroyed the purity of the crop if cultivated without constant attention.

The fourth selection was from a variety of red ear with yellow grains more peaked than the "Golden Drop;" these were all plump and well grown, but though of productive habits, afforded less flour and more bran than the white wheat varieties. I discovered a red variety among it bearing white grains, which I suspect to be very prolific and hardy. I gave a sample of it to Sir John Sinclair, who greatly encouraged me to prosecute my researches, as being of the highest importance. There were also red ears bearing liver-colored grains, but these were chiefly lean and ill grown. I generally, but not invariably, found that the grain of white wheat was the plumpest, or possessing the greatest specific gravity, or largest quantity of meal. The aspect of the grain in that dry season led me to think that white sorts of wheat will succeed best on dry soils and in warm climates, and that red and yellow, or the darker colored, prefer wet seasons or moist soils.

The care I took in making these selections, and the great number of sorts I found, of all shades and colors, forming varieties and sub-varieties, that are named by Professor LaGasca, confirmed my conviction that the only chance of having pure sorts, was to raise them from single grains or single ears. It is but fair to add, that even the pains I took in making those first selections, amply rewarded my labors, as the product of my crops was increased from an average about twenty-three or twenty-five bushels an acre to thirty-four, and since I have raised wheat from single ears or carefully selected sorts, I have increased my crops to between forty and fifty bushels the acre. Hence, I have no doubt, that with extreme care, in obtaining the best and most suitable sorts of wheat, land in high tilth, with fine cultivation, may be had to produce sixty or seventy bushels the acre.

Digitized by Google

CHAPTER IV.

ORIGIN OF THE WHEAT PLANT.

In Sicily, there is a wild grass known to botanists by the name of *Ægilops ovata.* It has been asserted that the seeds of this plant may be changed into wheat by cultivation; and that the ancient worship of Ceres, which considered the fields of Enna and of Trinacoria as the cradles of agriculture, had its origin in this transformation of the native grass.

The Ægilops are *hard*, rough-looking grasses, and there are several species of them. (See A, *a*, plate I).

The rough spiked Ægilops is a native of the Levant, and is the only perennial one.

The Cretan Ægilops is a native of Candia.

The cylindrical Ægilops is a native of Hungary, while the oval spiked and long spiked are natives of Southern Europe —mostly, however, from the northern shores of the Mediterranean—the oval spiked abounds in Italy. The seeds of the oval spiked or Æ. ovata very strongly resemble the seeds or grains of wheat, but are much smaller. In the Levant the Ægilops is gathered in bunches and burnt, and the roasted seeds are used as an article of food.

It had frequently been asserted that wheat and Ægilops were identical *species*, but no botanist, of any respectability, for a moment entertained the belief, from the fact that the latter is a miserable grass growing to the hight of nine or ten inches only, and in its general appearance, leaves so little resemblance to the former, that botanists have unhesitatingly classified them as belonging not only to different species, but to different genera! Pal de Beauvois, in 1812, in his valuable work on the genera of grasses, said that he could discover no difference between Triticum (wheat) and the Ægilops.

Digitized by Google

Three kinds of Ægilops are frequently met with in the south of France, and in other parts of the Mediterranean district, viz.: *Ægilops triuncialis*, L.; *Æ. ovata*, L.; and *Æ. triaristata*, Willd. M. Requien has stated that there is a fourth, which he calls Æ. triticoides; but this, as will be shown hereafter, is only a peculiar form of *Æ. ovata* and *triaristata*, both of which produce it.

1. Æ. triuncialis is distinguished from the others by its more slender and elongated cylindrical ears. The glume consists of two equal valves, one with three, the other with two awns. The nerves of the valves are seven to ten in number, and are, like the awns themselves, covered with asperities. The valves of the florets (paleæ), also two in number, are membranous and ciliated at their edge; one of them is terminated by three abortive awns.

The following stems are from thirty-five to forty centim.* high; the leaves are never so long as the spike. The ear itself is from ten to twelve centim. in length, and is composed of from five to seven spikelets, of which the three lowest are fertile, and the rest sterile. The glumes of the spikelets present projecting whitish ribs, varying in number with that of the awns which terminate them.

When the number of these awns is two, the number of the ribs of the glume is six or seven; when the glume has three awns, the number of ribs is commonly ten, five strong alternating with five slender.

The asperities which have already been stated to cover the sides of the glume, and the awns render both rough to the touch.

The seed or grain of this species are one centim. in length, horny, slender, not being more than three millim. in circumference at this largest part. Their upper end is terminated by a tuft of whitish silky hair. These grains are of a fine yellow color, and become brown when dried; they are a little

* 1 millimeter = 0.039 inch, or less than half a line. 1 centimeter = 0.393 inch, or nearly four-tenths of an inch.

Digitized by Google

flowery when broken. When germinating, only two radicles are usually produced; three are rare.

The plant is glaucous all over. Of all the species we shall have to notice, this is capable of being the most highly developed. It never produces varieties.

2. Ægilops ovata, L. (*a*, *b*, Plate I). The glume of this species is composed of two equal valves, each of which is terminated by four awns. The valves are marked with ten or eleven projecting nerves, of which six or seven are strong, and the others alternating are weak, and often incomplete; all are glabrous, or are furnished with very short hairs; the spikelets which they cover are strongly convex. (B, Plate I).

Of the two membranous valves, or paleæ, which compose the floret, one is terminated by three short awns, and the other has no beard, but is slightly ciliated at its apex. (F. Plate I).

The flowering stems are from twenty to twenty-five centim. in hight. The upper leaves never reach the first tooth of the axis of the ear. The ear, including the awn, is four centim. long; the end of the awn is violet colored. These awns spread so as to form nearly a right angle with the axis of the ear. The spikelets are four in number, and the two lower ones alone are fertile.

The ears of this species are shorter than those of any other. The fruit or grains are much shorter than those of Æ. triuncialis. Some are yellow and floury when broken; the others are black and horny. Three radicles are produced when the seeds germinate.

The whole plant is glaucous in appearance, and is thus easily distinguished at a glance from the other species.

3. *Ægilops triaristata*, Willd., differs from the two species just described in the following particulars: the two valves of the glume are equal as before, but they are almost always terminated by three awns, very rarely by two. The ridges and nerves of the valves are less numerous than in Æ. ovata The valves of the floret, or paleæ, are membranous, as in the other two species; but one is ciliated at its edges, and is ter-

Digitized by Google

minated by two short awns, while the other has no awn, and is ciliated at its apex. The awns are nearly vertical.

The flowering stem of this species are much more erect and taller than those of Æ. ovata; they are thirty to thirty-five centim. in hight. The upper leaves are longer, and almost reach the first tooth of the axis. The ears, including the awns, are five to six centim. in length, and are composed of from four to six spikelets, of which two, and sometimes three, are fertile. The nerves of the valves of the glumes are thickly covered with short hairs, and are consequently very rough to the touch. This species differ from the two preceding—

1. By the green color of all the parts of the plant.
2. By the breadth of the valves of the glumes.
3. By the very dark color which the ears assume when ripening.
4. By the larger size of its corn; and,
5. By the surface of the corn, which is covered with a sort of brown silk.

The color of the grain varies, some are yellow, and others are dark brown, or nearly black. The grains, when germinating, produce three radicles. They are floury, but harder than those of Æ. ovata.

4. *Ægilops triticoides*, Req. (*c*, Plate I). This plant was first described by M. Bertoloni. His description is of the plant found by Requien in the environs of Avignon and Nismes, in 1824, and named by him Æ. triticoides. In his herbarium there are specimens of the plant, and accompanying them are the following characters, which he assigned to it.

Leaves glabrous, grains pubescent. Ear composed of four or five spikelets; this ear is oblong, cylindrical, of the same length as that of Æ. triuncialis, and of the same size as of the ear of Æ. triaristata. The spikelets are four-flowered and glaucous. (D, Plate I). The valves of the glume are nearly glabrous, furrowed, with ribs rough to the touch; they are truncated and have two unequal awns, with one intermediate tooth. The exterior valve of the floret (E.) is terminated

Digitized by Google

by an awn nearly as long as, equal to, or sometimes longer than, that of the glume.

There ends the description. Now this Æ. triticoides of Requien, which is by its appearance so easy to distinguish from the other species, and is so clearly characterized, is not a distinct species; it is only a particular form assumed under certain circumstances, by the two other well-known species described above, under the names of Æ. ovata, L., and Æ. triaristata, Willd.

It is clearly ascertained that this is the case by the following observations, which can be easily verified by any one who will visit Agde in the month of May. It is very likely that they may be also verified in the environs of Nismes and Avignon, where M. Requien found his Æ. triticoides, and indeed wherever this form is met with.

The ears of Ægilops are coriaceous, and remain entire year after year without being decomposed; they merely become black as they become old. The grains of these ears do not fall from their envelops, but, when arrived at maturity, the ears break off from the top of the stem, fall upon the ground, and produce the next year new plants which spring from the whole ear; the spikelets do not separate from the latter, nor do the grains drop out from the spikelets. This may be seen from the specimens represented in Plate I, A.

The Ægilops are quick-growing plants; they germinate with the first showers in autumn, and emit, as we have said, three radicles from beneath the cotyledon.

When the ears begin to appear, it may be easily seen that the grains inclosed in the spikelets of the old ear on the ground produce two kinds of plants (see fig. 1, A.); the one kind terminating in shorter and more compact ears, and the other in ears which are much larger and of a very different form. The first are Æ. ovata, and the second Æ. triticoides.

The spikelets whose grains exhibit this phenomenon, are inserted on the same axis, and are consequently part of the same ear, and belong to the same individual plant.

Digitized by Google

The roots of the young plants shoot into the same soil, whence they obtain the same alimentary matters; nevertheless, the individuals called triticoides become the most highly developed, and assume different forms in all their parts.

It is clear from these observations, that the grains of the Æ. ovata, L., yield two sets of plants, viz.: those described under the name of Æ. ovata, and those which Requien and Bertoloni thought a distinct species, and named Æ. triticoides. This is not all. Another species of Ægilops, Æ. triaristata, Willd., also yields the triticoid form, distinguishable, however, from that produced by Æ. ovata.

The ears of Æ. triticoides, obtained from Æ. ovata, are glaucous and many-flowered in their spikelets, have more flowers, and are packed closer to each other; while the ear of Æ. triticoides, yielded by Æ. triaristata, are yellow, sometimes become blackish-brown, and are besides alternate flowered, and are formed of spikelets with fewer flowers, tolerably distant from each other, and so arranged that this alternation is very distinct.

The species of Ægilops are common in the south of Europe, and probably in the whole basin of the Mediterranean. They inhabit flat, hot, dry plains. I found some of Æ. ovata presenting at the same time both the form characteristic of this species and that of the triticoides, in an uncultivated volcanic soil, with a sub-soil entirely of porous lava; it is the hottest and driest soil of the country, and is known by the name of *Rocher de Rigand;* around it grow some very weak vines.

The Æ. triaristata presented the same phenomenon as the Æ. ovata in a very barren, gravelly soil, covered with pebbles. The remarkable fact that, under certain circumstances, plants approaching Triticum, or wheat, are produced from the two perfectly distinct species of Ægilops, lead to the supposition that, as has often been presumed, these Ægilops are the wild representatives of cultivated grain, and that consequently wheat is nothing more than Ægilops modified by the influence of soil and climate.

Digitized by Google

It may, moreover, be supposed that the varieties of Triticum, or wheat, produced by Æ. ovata, are those with glabrous ears and fine grains, known to agriculturists by the name of *Seissette*, *Touzelle*, glabrous, or bearded, etc., and which varieties were long since united by M. Dunal into one great class, called *Touzelle*, and so adopted by M. Seringe, in his excellent work on cereals. It may also be presumed that the coarse grain, with hairy spikes, known in Languedoc by the name of Froment, including *Triticum turgidum*, and *compositum*, and forming the group called Petanaille by M. Dunal, arise from Æ. triaristata, Willd. It would result from this, that the two species of Ægilops which are transformed into triticoides, give rise to two series of distinct varieties, each consisting of one of the known groups, races, or varieties of cultivated wheat.

Before it had been ascertained by observation, that Æ. triaristata presented the same phenomenon as Æ. ovata, that is to say, yielded plants like Triticum, Æ. triticoides derived from ovata, was cultivated in the hope of obtaining cultivated wheat, or at least some analogous variety.

Mons. Esprit Fabre, of the town of Agde (France), made a very important discovery, alone, unaided by books, and entirely without any knowledge of researches or investigations in this direction, other than his own. He brought to the notice of scientific men a fact which goes far to establish not only the mutability of vegetable forms, but the more important fact that *wheat* is derived from the Ægilops mentioned in a preceding paragraph. There is no fact in Natural History more pregnant in its consequences to the civilized world than this one. The following details of his experiment are condensed from the Journal of the Royal Agricultural Society:

"In 1838 he found the grasses of *Ægilops ovata* and the *Æ. trianistata* growing wild in his immediate neighborhood, and sowed the seed of the ovata in the fall of the same year. In 1839 the plants attained a hight of two to two and a half

Digitized by Google

feet; these plants ripened from the 15th to the 20th of July. There were very few fertile spikelets or breasts—each having one or two grains only, which ripened late; the remaining spikelets were sterile by abortion. The entire crop did not produce to exceed in a five-fold proportion; the grains were close, concave, and very hairy at the top. The straw was very thin and brittle, the ears deciduous, that is, they broke and fell as soon as ripe. Each valve of the glume had two arms only, one shorter than the other. In one plant one of the arms became abortive, and there only remained one to each valve of the glume. On others there were some glumes with a long, and others with a short beard. These plants had exactly the appearance of Touzelle wheat. In some the angles of the *rachis*, or that portion known as the *back-bone* of the ear—a continuation of the stem on which the seeds in the chaff are attached, were strongly *ciliated*, or fringed with hairs. Sowed seeds obtained from these plants, and

"In 1840, at harvest, the spikelets were more numerous, and contained two grains. The valves of the glumes terminated in two awns, or beards, of which one was four or five times shorter than the other—sometimes reduced to a mere tooth only. Fruit—the grains—less compact, less concave, and less hairy at the end; angles of rachis were less ciliated, and the ears were somewhat less deciduous. The grains contained more flour than those of the preceding year. Sowed the seeds of these plants, which

"In 1841 produced ears like those of Triticum (true wheat). A very remarkable and important change occurred in this crop. There were no barren spikelets, and all of them were like wheat in every respect, each one bearing two or three perfectly developed seeds. The contour of the entire plant more strongly resembled that of wheat. The seeds were less concave and hairy than the preceding year. The valves of the glumes had each two arms, one of which was very long, while the other was so completely abortive as almost to justify

Digitized by Google

the statement that the awns were single. These seeds were planted, and

"In 1842 the plants were attacked by rust. Less progress was made than in the preceding year; the stalks retained much of the bitterness peculiar to the Ægilops, the ears were remarkable for the small development of awn, and had exactly the appearance of the beardless Touzelle wheat. Twenty of the ears were entirely sterile. The plants which were not affected by the rust had deciduous ears, the awns of which were less abortive. Many of the spikelets had three flowers, and yielded two or three good grains, which were slightly heavy at the apex. These seeds were sown, and

"In 1843 the plants attained the hight of three feet; the straw assumed a more firm and less brittle texture. One of the two awns was so short and rudimentary that these valves may, with propriety, be considered as having one awn only. Each spikelet had two and sometimes three fertile flowers. The grains were so well developed that they were exposed through the valves of the florets; the ears were less fragile and exactly like wheat in appearance. One of these plants yielded 380 grains for the one sown, and another yielded 450 for one; these grains protruded through their covering. The crop had

"In 1844 all the spikelets fertile and a quantity of them contained three grains. These grains were visible through their envelopes, and were concave on one side; the spikes or ears were deciduous. The valves of the glume had one long awn with an exceeding short rudiment of another.

"In 1845 the crop was adjudged by all to be true wheat; the valves of the glumes had one awn only with a mere tooth of another. The spikelets had four or five flowers each, three of which were fertile. It is now regarded by Mons. Fabre as being true wheat, or rather that the Ægilops had been brought to its highest state of perfection; therefore,

"In 1846 the crop grew in an open field. The field select-

Digitized by Google

ed was one near the road leading to Marseillan; the soil of which was called *souberbe.* The field was inclosed on all sides by vineyards. Care was taken to prevent any pollen from Ægilops from falling on it. During the four succeeding years the yield was six to eight times the seed sown.

"The character of these plants in 1850 were briefly as follows: stems straight, having attained a hight of about thirty inches and *full of pith.**

"The valves of the glumes terminated in a single awn, the rudiment of the other scarcely visible, slightly striated and almost hairless. The two valves of the florets were membranous as in Ægilops, but the exterior one had a single awn only, while the other had none. The ears had from eight to twelve spikelets, having two or three fertile flowers, and each producing two or three grains; these grains were very floury

---

Solid Stem Wheat.—We had an opportunity a few days since of seeing a lot of wheat upon the farm of Dr. Wilson Waters, of Rhode river, from which, we presume, upward of a bushel will be reaped—that if we mistake not, will be a valuable acquisition: it is the third produce of a few grains of seed brought home by our fellow citizen Lieut. Mayo, of the United States Navy, and obtained by him upon the plains of Troy, in Asia Minor, where he spent some time in visiting a few years ago, when the ship on board of which he then served, was in the Archipelago. The grains of this wheat are somewhat larger than those of wheat common to this country, though perhaps not quite as large as the wheat from the mountains of Chili. The stalk is peculiar for being nearly solid, instead of hollow, and more tapering than other wheat; the first joints being large, and forming a more substantial base. The head has a thick stiff beard, not less than six inches in length. It averages about forty grains to each head. Forty grains of the former weighed thirty-one grains—the same number of the latter weighed but nineteen grains. This being the third year that this wheat has vegetated in our climate and upon our soil, although but in specimen, we may fairly assume that it has been tested and found to answer well.

It is said to be valuable, more especially from the protection which the solidity of its stalk affords from the depredations of the fly, so destructive to other descriptions of wheat. It will also be much less liable to fall, we presume, for the same reason.—*From the American Farmer, Vol.* 13, *July* 22*d*, 1831.

Digitized by Google

and very little concave. The yield of 1850 was less than that of the three preceding years; this diminished product was undoubtedly owing to the drought which prevailed that year in France."

After having cultivated it for twelve successive years, Mr. Fabre says that it has become perfect wheat, and that not a single plant has ever reverted to its former character as Ægilops. The entire series of this experiment were conducted by Mr. Fabre (who is a "simple gardener") in person; they were therefore conducted by one who was not only skillful but eminently a practical man; one who had a practical knowledge of the culture of plants, and not by a theorist or amateur deeply interested in obtaining a special result, and whose desire of success would induce him to hybridize with genuine wheat annually until the Ægilops element would be entirely absorbed. Mr. Fabre had the precaution to conduct all these experiments in an inclosure surrounded by high walls, where was no grain grown anywhere near the inclosure. Mr. F's industry would permit no grass to grow on the inside of the inclosure. It would be gratuitous to suppose that the pollen of wheat in the vicinity could exert any influence on these plants,* because the wild Ægilops growing all about the edges of the fields, has never had its character changed in consequence of the proximity.

In proof that Mr. Fabre's experiments were real and beyond all cavil of being an imposition, Mons. Dunal, Professor of Science at Montpelier, one of the most competent men to decide such a question, has preserved dried specimens of Fa-

* In Abels "*Aus der Natur*," Vol. 8, page 271, speaking of Fabre's experiment the writer remarks, "What is more probable than that these plants were fertilized by the pollen from true wheat plants in the immediate vicinity, especially when it is a well known fact that when the wheat is in bloom, entire clouds of pollen grains may be seen rising from the wheat fields on a clear day!" Those who have undertaken to hybridize wheat will at once know how much reliance may be placed on this statement, especially after Gærtner has testified that the cereals are the least favorable of all plants to hybridization.

Digitized by Google

bre's Ægilops, at every stage of its transformation to wheat, and offers them as substantial evidences of the fact.

In whatever light, and from whatever stand-point we may view this series of experiments, the result certainly is pregnant with the most important consequences. If wheat is to be regarded only as Ægilops, fully and perfectly developed by cultivation, then is *one* position assumed by a party of disputants or rather theorists fully affirmed, namely: that plants by and through climate, soil, position and cultivation, may permanently change their characteristics. It may however be claimed that no observations have been made of the degeneracy of the wheat plant, and for aught that is known to the contrary that it in many instances *may have* reverted to its original type and character of Ægilops; but on the other hand we have generally received and accredited records which contain sufficient accounts of the wheat plant to justify the assertion that it has been cultivated upward of five thousand consecutive years, and in all this time there is no instance on record of its degeneracy, other than its increased liability to disease. An uninterrupted transmission of qualities or characteristics for the number of consecutive years just mentioned must be regarded as *approximating* permanency—at least for all practical purposes. But if on the other hand, wheat must be regarded as of an allied genera of the Ægilops, it proves that botanists were not sufficiently familiar with the character of the plants when the classification was made.

Mons. Godron, a French botanist, and Mr. Buchinger, a German botanist, have both been surprised by, and mortified at the result of "simple-minded" gardener's experiments. It appears that in a wild state the *Ægilops ovata* gives rise to a variety known by botanists *Æ. triticoides*, which the *Æ. ovata* in one of its transformations toward wheat very much resembles. Upon this *resemblance* Mons. Godron undertakes to impeach the integrity of Mr. Fabre in a lengthy paper which he has published, and in which he maintains that Æ. triticoides is *not* a condition or variety of Æ. ovata, but that it is a hybrid

Digitized by Google

between the ordinary wheat and the latter plant! Buchinger indorses Godron, and directly charges Fabre with hybridizing with wheat pollen. In their anxiety to disprove the truth of the experiment, all these old-school botanists forget that they are acknowledging that wheat and Ægilops will hybridize, and the hybrid propagate its kind in direct conflict with the generally received opinion on this subject, thus admitting that *Æ. ovata* is more closely related to *Triticum sativum* than *T. caninum* or *T. cristatum* are, because neither of these latter two will hybridize with *T. sativum*. They forget also that they are paying Mr. F. the highest compliment possible in acknowledging that by his skill he could produce a hybrid between two widely distinct genera of plants, and that this hybrid would perpetuate itself. It may be making an assertion which may perhaps not ultimately be borne out by the facts, but there are many indications in the recent developments of physiological science, that there can be no fertile hybrids except those produced by varieties of the same species of plants upon each other. If then this position is found to be a tenable one, it follows that in future the genera TRITICUM, or that of Ægilops must be stricken from works on systematic Botany.

It may be well to recapitulate in detail the changes produced in the plant itself by Mr. Fabre's culture. In its natural state the *Æ. ovata* is glaucous that is, covered with a whitish bloom which rubs off, as the surface of a cabbage leaf or a plum in all its parts; its flowering stems never exceed nine to ten inches in hight; the upper leaves never reach the first tooth of the rachis of the ear; the last is short and oval, has four spikelets only, and of these the two lower ones alone are fertile. A *variety* of the *Æ. ovata* is called *Æ. triticoides*, in which one or two of the awns of the *ovata* disappear, so that the valves of the glume of the greater part of the spikelets have only two long awns instead of four in the lower spikelets. The outer membranous valve of the floret, instead of terminating in three awns, has only one, at the base of

Digitized by Google

which may be seen the two rudiments of those which are wanting. The other membranous valve is without a beard, and is fringed at its summit. The ears are formed like those of the *ovata* of three or four spikelets, generally sterile, rarely fertile. The florets are hermaphrodite, that is containing the reproductive organs of both male and female, and inclose three stamens around a pistil ending in two long silky stigmas. These florets are often sterile or barren in consequence of the abortion of the pistil. The grains of the fertile ones are elongated, angular, very concave, and sometimes flattened on one side; color yellow, approaching blackness like that of the *ovata*, but is longer and is silky at the top. When these grains were sown and cultivated for the first time they yielded plants three or four times as high; ears were cylindrical and much more elongated than those of the parent plant—the valves of the glumes had only two awns, one was shorter than the other, occasionally one was almost entirely absent, so that each glume had one awn only. The awns of some plants were very long, while others were very short; the plants assumed the appearance and characters of *Triticum* more and more. The spikelets more numerous than in the parent plant, were often sterile, and the few which were not had one or two fertile flowers only, so that the fertile spikelets had no more than one or two grains. These grains, the next year, produced more perfect plants—their spikelets were more numerous than before, and almost all of them contained two fertile flowers and yielded two grains. The awns were always two in number, but the abortion of one was in every case carried further than previously, and often was complete. The grains were less compact, less concave, less hairy at their extremity. The ears when ripe separated less easily from the axis and the grains were each successive year more floury. The third year produced plants more perfect than the second—scarcely any sterile spikelets, each of which yielded two and sometimes three grains, more developed, less concave and less hairy. The fourth year produced no notable change. The fifth year

Digitized by Google

produced plants a yard in length; grains sufficiently developed to separate the valves of the floret and to be wholly exposed when ripe—mature ears less deciduous. The following year all the spikelets were fertile, although the ears separated with ease. The next year the ears did not break off easily; all the spikelets were fertile and occasionally inclosed three well developed grains, a true Triticum was produced, for cultivation in the open field for four successive years did not cause any change in form, and the product was similar to that of other wheat.

The changes in the form and character of the plant are by no means accidental, but are in accordance with a law which although but little known, is daily more and more observed and acknowledged. The celebrated Dr. Arnott affirms that in all the numerous instances of abnormal structures that had come under his observation, on at least thirty different genera of grasses, the universal tendency of the spikelet was to elongate its axis, and increase the number of its flowers;* but he never in one solitary instance observed them to become fewer flowered than in the normal state.

Assuming that Fabre's experiment was successful, the legitimate inference will be that some at least, if not all of the cultivated *Tritici* are peculiar forms of Ægilops and should be regarded as races of this species. This will reconcile the traditions, the vague and disconnected accounts of the origin of wheat, which in ancient as well as in modern times, was claimed to be found wild in Babylonia, Persia and Sicily. In all these countries the Ægilops is a very common plant, and some of its species may have accidentally acquired a wheat-like appearance.

* It is well known that the Dahlia, Rose, Chrysanthemum and other flowers, all have a tendency to increase not only the number of their flowers, but also the petals in each flower by cultivation.

Digitized by Google

CHAPTER V.

STRUCTURE AND COMPOSITION OF THE WHEAT GRAIN.

SCARCELY any plant has been so frequently made the subject of analysis as the wheat plant, and no cereal has been analyzed by so many chemists as has the wheat grain.

As there are several kinds of analyses, it is important that the result of each kind in relation to wheat be placed before the reader. Analysis is either qualitative or quantitative; that form of analysis which determines what *kind* of material enters into the composition of any substance is termed *qualitative* analysis, but that which determines the *amount* of each ingredient is termed *quantitative*.

The simplest qualitative analysis to which wheat may be subjected is a *mechanical* one, viz.: grinding in a mill; by this operation is obtained flour and bran. From either the flour or bran further qualitative analyses may be made and the result will be starch, gluten, etc. It is always desirable to obtain quantitative as well as qualitative analyses. One hundred pounds of the wheat grain, flour, and bran analyzed according to the methods just named is as follows:

QUALITATIVE.	QUANTITATIVE.		
	Wheat.	Flour.	Bran.
Water	14.88		
Gluten	19.64	13.04	20.0
Albumen	0.95		
Starch	45.99	78.20	
Gum	1.52	4.20	28.8
Sugar	1.50	5.6	
Oil	0.87	2.1	5.5
Vegetable fiber	12.8		45.7

But when chemists analyze organic substances as wheat for example, they first burn it in order to reduce it to ashes. The

Digitized by Google

parts given off by the process of burning are gases, but the ashes contain all the earthy substances of which the material was composed. From the ashes of 100 pounds of wheat are obtained, according to the variety of wheat, from one and a half to two pounds of ashes, which the chemist says are composed of

Potash	29.97	per cent
Soda	8.90	"
Magnesia	12.30	"
Lime	3.40	"
Phosphoric acid	46.00	"
Sulphuric acid	0.33	"
Silica	8.85	"
Peroxide of iron	0.79	"
Chloride of Sodium	0.09	"
	100	

From this it will be seen that the ash of wheat is rich in phosphoric acid, magnesia and potash.

But the gluten, albumen, starch, gum, sugar, etc., of which wheat is composed may be further analyzed and converted into the original elements, thus:

	Gluten.	Albumen.	Starch.	Gum.	Sugar.	Vegetable Fiber.
Carbon	53.27	53.74	42.80	42.68	36.1	53.23
Hydrogen	7.17	7.11	6.35	6.38	7.0	7.10
Nitrogen	15.94	15.66				
Oxygen, Sulphur, Phosphorus	28.62	28.50	50.85	50.94	56.9	16.41 / 23.35

The oil for the greater part consists of carbon. The gluten, and consequently starch, is found to vary considerable in different varieties of wheat, as well as in wheat grown in different latitudes.

Digitized by Google

The analyses by Peligot are referred to by Morton, in the Encyclopedia of Agriculture:

	White Flemish.	Hardy White.	Odessa.	Polish.	Banat.	Egyptian.	Spanish.	Taganrog.	Average.
Water	14.6	13.6	15.2	13.2	14.5	13.5	15.2	14.8	14.0
Gluten and albumen	10.7	12.5	14.3	21.5	13.4	20.6	10.7	13.6	12.8 / 1.8
Starch	61.0	59.1	59.6	53.4	62.2	55.4	61.9	57.9	59.7
Gum and sugar	9.2	10.5	6.3	06.8	5.4	6.0	7.3	7.9	7.2
Cellular fiber	1.8	1.5	1.7	1.7	1.7	1.7	1.7	2.3	1.7
Oil	1.0	1.1	1.5	1.5	1.1	1.1	1.8	1.9	1.2
Mineral matters	1.7	1.7	1.4	1.9	1.7	1.7	1.4	1.6	1.6
	100	100	100	100	100	100	100	100	100

From this it will be seen that of the above varieties grown in England, the White Flemish yields a minimum amount of gluten, the Polish yields the maximum; but at the same time it yields a minimum of starch, while the Banat, which yields a medium proportion only of gluten, yields the largest amount of starch.

Mr. Lewis C. Beck, of Rutger's College, N. Y., in 1848–9, made analyses of wheat and flour from Europe, as well as many from samples grown in the United States, with direct reference to their "relative value and the injury which they sustain by transport, warehousing," etc., analyzed specimens of wheat and flour from Russia, Poland and Holland—the specimens were forwarded to him from Amsterdam; the analyses from these specimens, as well as some of those from wheat and flour, the product of the United States, will be found in the annexed table:

	Water.	Gluten and albumen.	Starch.	Glucose, Dextrin, etc.	Bran.
New Brunswick, N. J	12.75	10.90	70.20	6.15	.....
" " damaged	12.35	8.31	(79 34)		.....
Genessee wheat, N. Y	12.40	11.46	70.20	5.20	.....
Zanesvile, O	12.85	14.25	37.06	5.98	.....
Empire Mills, Roscoe, O	13.00	10.00	70.20	6.80	.....
Venice Mills, O	12.36	12.60	(75 04)		.....
Ohio wheat, fine	12.85	12.25	(73 90)		1.00

Digitized by Google

	Water.	Gluten and albumen.	Starch.	Glucose, Dextrin, etc.	Bran.
Ohio wheat, superfine	13.00	9.10	(77 80)		.10
" winter wheat	13.10	11.50	66.84	7.90	.60
" " " second grinding	13.05	12.69	(73 61)0		.65
Forest Mills, Logansport, Ind.	12.85	11.90	67.00	8.25	.....
" " (damaged)	13.00	7.00	67.80	11.30	.....
Rock River, Ill.	13.87	9.90	(75 88)		0.35
Bruce's Mills, Mich.	13.20	11.85	65.60	8.60	0.45
Monroe, "	13.10	10.40	(76 30)		0.20
Wisconsin wheat	13.80	10.85	67.00	8.33	.....
Georgia "	11.75	14.36	68.93	4.96	.....
Turk's Island, W. I.	12.60	12.70	66 —	8.50	.....
Zealand wheat	13.40	10.25	69.65	6.70	.....
Poland "	13.00	10 05	68.15	7.60	.....
Soft Petersburg wheat	13.20	11.00	69.00	6.80	.....
Friesland "	13.90	10.00	69.75	6.10	.....
Kubanka "	12.35	16.00	59.65	9.00	2.90
Pennsylvania "	11.90	13.16	66.20	7.25	0.75
Missouri winter wheat	14.00	9.30	70.05	6.30	0.35
Maryland wheat	13.00	12.30	66.65	7.10	0.65
Virginia superfine	12.05	12.95	(74 50)		0.50
Chilian wheat	12 85	8.65	71.60	6.10	.60
Spanish "	13.50	10.30	68.90	7.00	.30

In addition to this statement, the following analyses may with propriety be here inserted:

	Vauquelin.		Dumas.		Beck.
	Flinty Wheat.	Soft Wheat.	Flinty Wheat.	Soft Wheat.	Flinty Wheat.
Water	12.00	10.00	12.00	10.00	12.40
Gluten	14.60	12.00	14.55	12.00	11.46
Starch	56.50	62.00	56.50	62.00	70.20
Sugar	8.50	7.40	8.48	7.36	5.20
Gum	4.90	5.80	4.90	5.81	
Bran	2.30	1.20	2.30	1.29	.....

Professor Emmons, of New York, made many analyses of wheat, wheat straw, and chaff, grown in the State of New York, from which the following extracts are made:

"Many difficulties exist in the analysis of the grain of the cereals, and particularly in wheat and Indian corn. In consequence of this fact in part, I regret that I am unable to give a full account of the composition of the former. But this is not all. I have been poorly supplied with samples of the grain; and not living in a wheat district, I have been unable to procure it, either in a ripe condition, or in its dif-

Digitized by Google

ferent stages of growth. I made repeated applications, both to the members of the Agricultural Society, and to other individuals, but only in two or three instances have my applications been successful. I availed myself, however, of several fine samples of wheat, furnished by Mr. Harmon. These, although the straw was in sufficient quantity for analysis, the grain itself was insufficient in amount to answer well that object. I have, however, made as good a use of the means within my reach, as I was able; and I propose now to enter upon the details, as far as I am able at the present time:

I. *Winter Wheat from Genesee County. Received from Mr. Peters. The variety not given.*

Specific gravity	1.289

PROPORTIONS.

Grain	1000.00
Ash	1.450
Straw	100.000
Ash	2.660
Chaff	100.000
Ash	7.970

From these proportions, I obtained from the ash of the grain, Silica, 0.075; Phosphates, 0.810; from the straw, Silica, 1.285; Phosphates, 0.070; from the chaff, Silica, 6.435; Phosphates, 0.080.

The phosphates were obtained by precipitation by caustic ammonia, and hence the full amount of phosphoric acid does not appear in the grain.

Analysis of the ash of Mr. Peter's winter wheat. Effervesces slightly on the addition of acid.

Sand	8.525
Silicic acid	1.700
Phosphoric acid with part of the magnesia	60.725
Lime	0.050

Digitized by Google

Magnesia	2.880
Potash	7.180
Soda	16.920
Sodium	0.195
Chlorine	0.295
Sulphuric acid	0.895
Organic acids	2.400
Carbonic acid not determined	
	96.775

2. Organic Analysis.

100 grs. gave as follows:

Starch	61.400
Albumen	1.215
Gluten	4.460
Casein	trace.
Matter dissolved out of epidermis and other bodies insoluble in water and alcohol, by acetic acid	1.980
Matter dissolved out of epidermis and other bodies insoluble in water, alcohol and acetic acid, by a weak solution of caustic potash: comports itself like albumen	1.480
Epidermis after digesting in alcohol, acetic acid, and potash	3.410
Dextrine	2.400
Water	9.380
Oil	1.050
Extractive matter and sugar, and loss	13.225
	100.000

This analysis is not complete: the extractive matter and sugar were not obtained.

PROPORTIONS.

Water	9.380
Dry matter	90.620
Ash	1.650
Ash calculated on dry matter	1.281

Digitized by Google

II. *Black-Sea Wheat from Lewis County. Soil slaty, being based upon the Utica slate.*

1. ANALYSIS OF THE ASH.

		Removed from an acre.
Silica	4.300	0.970 lbs.
Phosphate of lime, magnesia and iron	45.376	10.240
Phosphate of the alkalies	28.395	6.363
Potash	10.330	2.444
Soda	8.110	1.830
Lime	0.010	0.002
Magnesia	0.020	0.004
Organic matter		
Carbonic acid	1.340	0.301
	98.221	22.154

2. ANALYSIS OF THE EARTHY PHOSPHATES.

		Per centum.
Soluble silica	0.008	0.074
Lime	1.940	2.380
Phosphate of peroxide of iron	1.880	4.470
Magnesia	2.920	12.440
Phosphoric acid	12.825	80.760

III. *Black-Sea Wheat from the same County.*

Specific gravity 1.341. Kernel small, and but little lighter colored than the best kinds of rye. Soil based upon limestone.

ANALYSIS OF THE ASH.

Sand	3.700
Silicic acid	1.550
Phosphoric acid with part of the magnesia	62.075
Lime	0.050
Magnesia	3.485
Potash	8.045
Soda	14.790
Sodium	0.320

Digitized by Google

Chlorine	0.490
Sulphuric acid	0.340
Organic acid	2.000
Carbonic acid not determined.	
Effervescence very slight on adding acid to ash.	
	96.795

IV. *Analysis of Summer Wheat, received from Mr. Peters, of Genessee County.*

		Removed from the acre.
Silica	2.633	0.687 lbs.
Sand	1.607	0.419
Phosphates of lime, magnesia and iron	48.000	12.528
Phosphates of the alkalies	19.440	5.078
Lime and magnesia	0.020	0.005
Potash	14.720	3.841
Soda	3.356	0.875
Chlorine	none.	
Sulphuric acid	0.544	0.141
Organic matter	8.480	2.213
	98.864	25.782

Percentage of water of Black-Sea Wheat on different soils.

On limestone	10.52
On slate	10.72
On alluvial gravel	10.27
On Sandy soil	11.10

The variety known as Harmon Wheat, grown upon clay loam based upon the rocks of the salt group, gave water 11.82, after long drying in the water-bath. The last had assumed a brown color, and appeared partially charred, although it had never been exposed to a temperature above 212 ° Fahr. From the preceding observations, and others of the same kind, I am led to believe that this grain has always in combination, about the same quantity of water, and that soil and varieties do not cause it to vary much either way from 12 per centum of water. This amount of water, however, although it is comparatively small, has probably a de-

Digitized by Google

cided influence upon its preservation in transportation to foreign countries. The hygrometric power of grains and flour has not been determined. The percentage of water may not of itself form an obstacle to its keeping; and if it is not in a situation to imbibe more, it may perhaps remain for years in a sound state.

V. *Black-Sea Wheat from Lewis county. Grown upon the Trenton Limestone.*

ANALYSIS OF THE ASH.

Silica and sand	14.520
Earthy phosphates	43.333
Alkaline phosphates	23.646
Potash	12.629
Soda	5.068
Magnesia and lime	0.080
Chlorine	trace.
Sulphuric acid	trace.
Carbonic acid	none.

VI. *A Winter Wheat from the same county. Grown upon sandy soil. Variety not given. Furnished by Mr. Beach.*

ANALYSIS OF THE ASH.

Silica	9.120
Sand and coal	10.000
Earthy phosphates	48.278
Alkaline phosphates	15.501
Potash	23.407
Soda	4.044
Lime	0.020
Magnesia	0.002
Sulphuric acid	trace.
	100·367

ANALYSIS OF THE EARTHY PHOSPHATES.

Soluble silica	0.08
Lime	1.98
Phosphate of peroxide of iron	4.95
Magnesia	6.64
Phosphoric acid	28.31

Digitized by Google

VII. *Winter Wheat from the same county. Furnished by Mr. Beach. Grown upon a gravelly soil.*

ANALYSIS OF THE ASH.

Silica and coal	12.134
Earthy phosphates	37.072
Alkaline phosphates	21.813
Potash	22.496
Soda	7.848
Chlorine	trace.
Sulphuric acid	trace.
Magnesia and lime	0.031

NOTE.—I was desirous of repeating all those analyses in which so much foreign matter, as coal and sand, existed. Experience subsequently enabled me to avoid this objectionable state of the ash; still the results are correct for all the elements except silica. In regard to this, I have been satisfied that it varies from 1.50 to 5 per centum; and it is probable, in those varieties grown upon soils of Lewis county, that they reach the maximum percentage. The grain has a thick cuticle, and is rather dark; and it is in these kinds that the silica is in the largest proportions.

VIII. *Straw and Chaff of Wheat from Mr. Peters.*

1. ANALYSIS OF THE STRAW.

		Removed in a tun of straw.
Silica	49.100	29.255
Earthy phosphates	19.600	11.678
Lime	8.460	2.061
Magnesia	0.824	0.198
Potash	22.245	13.253
Soda	5.195	3.095
Sulphuric acid	8.876	0.521
Chlorine	0.121	0.072
	100.921	60.128

Digitized by Google

2. ANALYSIS OF THE CHAFF.

		Removed in a tun of chaff.
Silica	80.60	148.893
Earthy phosphates	8.80	15.710
Carbonate of lime	4.70	8.390
Magnesia		
Potash	1.80	3.213
Soda	3.20	5.712
Sulphuric acid	1.21	2.160
Chlorine	trace.	
	100.31	179.078

PROPORTIONS OF GRAIN, STRAW AND CHAFF OF SEVERAL VARIETIES OF WHEAT.

1. Old Red-chaff Wheat—	Actual quantities.	Per centum.
Grain	7.24 grs.	100.000
Chaff	2.21	30.524
Straw	11.54	159.392
2. Talavera Wheat—		
Grain	12.40	100.000
Chaff	2.92	23.548
Straw	14.44	116.209
3. Indiana Wheat—		
Grain	556.50	100.000
Chaff	129.50	23.270
Straw	611.00	109.811
4. Improved Flint Wheat—		
Grain	11.30	100.000
Chaff	2.72	24.070
Straw	13.23	117.079
5. Harmon Wheat—		
Grain	1207.50	100.000
Chaff	300.00	24.844
Straw	1166.50	96.604

To determine the foregoing proportions of grain, etc., I took from a small bundle those heads and straw which remained perfect, a certain number, and shelled the grain, and weighed each part by itself. This method of determining the proportions of grain, chaff and straw, has been found as correct, if not more so, as weighing large quantities in the usual

Digitized by Google

way. Due care must, of course, be taken to avoid losses in separating the grain.

IX. *Improved White-Flint Wheat.*

ANALYSIS OF THE STRAW.

Silica	42.60
Carbonate of lime	8.90
Phosphates of lime, magnesia and iron	9.30
Potash	22.76
Soda	5.28
Magnesia	1.58
Sulphuric acid	5.85
Chlorine	1.86
	98.13

X. *Old Red Chaff Wheat.*

ANALYSIS OF THE STRAW.

		Removed in a tun of straw.
Silica	70.00	78.40 lbs.
Coal	0.25	0.28
Phosphates of lime, magnesia and iron	8.89	9.95
Carbonate of lime	1.80	2.01
Magnesia	0.15	0.16
Potash	12.12	13.57
Soda	4.19	4.69
Sulphuric acid	2.25	2.52
Chlorine	1.75	1.94
	101.50	113.52

The straw of the Old Red Chaff is stiff and rigid; and from its characters alone it would be inferred that it contained a greater percentage of silex.

XI. *Wheatland Red Wheat.*

ANALYSIS OF THE STRAW.

		Removed in a tun of straw.
Silica	15.75	84.84 lbs.
Phosphates	8.21	9.19
Carbonate of lime	1.05	1.17
Magnesia	0.25	0.28

Digitized by Google

Potash	7.20	8.06
Soda	2.10	2.85
Chlorine	0.24	0.26
Sulphuric acid	2.21	2.47
	97.01	108.62

XII. *Soule's Wheat. Specimen taken from the State Agricultural Rooms. Fine plump berry.*

		Calculated on dry matter.
Starch	62.29	68.860
Sugar and extractive matter, with a little acid, formed during the analysis	6.40	7.028
Dextrine or gum	1.21	1.828
Epidermis	7.20	7.908
Matter dissolved out of epidermis and other bodies insoluble in water and boiling alcohol, by a weak solution of caustic potash	6.82	7.485
Oil	1.02	1.119
Gluten	4.51	4.949
Albumen	1.67	1.833
Casein	trace.	trace.
Water	9.79	.....
	100.91	100.000

The gluten in the above analysis is small, though, I think, correct. The matter insoluble in water was digested in successive portions of boiling alcohol for six hours, till nothing more was taken up. The matter insoluble in water and boiling alcohol was digested in a weak solution of caustic potash, which took up over seven per centum of the dry grain; which, if albumen, increases that body to a large percentage. The gluten and starch agree nearly with the winter wheat from Genessee, but the albumen and epidermis are much greater.

PROPORTIONS.

Percentage of water	9.790
Percentage of dry matter	90.210
Percentage of ash	1.720
Percentage of ash calculated on dry matter	1.906 S.

Digitized by Google

XIII. *Provence Wheat.*

ANALYSIS OF THE STRAW.

Silica	68.60
Phosphates	4.70
Carbonate of lime	2.85
Magnesia	1.35
Potash	5.55
Soda	5.68
Sulphuric acid	2.88
Chlorine	1.34
Organic matter	4.20
Carbonic acid	1.40
	97.95

XIV. *Hopetown Wheat.*

[Length of straw, forty-four inches.]

1. Relation of grain, straw and chaff—	Actual quantities.	Per-centage.	
Grain	12.07	42.30	
Straw	14.23	49.86	57.70
Chaff	2.24	7.84	
Specific gravity of the grain	1.391		

2. Percentage of water and ash—	Water	Ash.	Ash calculated dry.
Grain	1.25	1.76	2.01
Straw	13.7	4.16	4.82
Chaff	11.5	10.36	4.82

3. Produce, and mineral matter of an acre—		Mineral matter.
Grain	22.16	43.5
Straw	25.94	120.4
Chaff	4.11	57.6

4. Analysis of the ash of the grain—		Removed from an acre. lbs.	oz.
Silica	8.20	1	6.6
Phosphoric acid	44.44	19	6.0
Sulphuric acid	trace.		
Carbonic acid	none.		
Lime	8.21	3	9.2
Magnesia	9.27	4	8.3

Digitized by Google

Peroxide of iron	0.08	0	0.9
Potash	32.14	17	13.8
Soda	2·14	1	8·8
Chloride of sodium	none.		
	99.97	48	9.7

5. Analysis of the straw and chaff—

		Removed from an acre.	
Silica	67.10	119	6.8
Phosphoric acid	6.05	12	8.7
Sulphuric acid	5.59	91	5.2
Lime	4.44	7	14.4
Magnesia	3.27	5	13.0
Peroxide of iron	1.54	2	11.8
Potash	10.08	17	13.6
Soda	0.85	1	8.6
	99.97	177	11.5

The foregoing extract, exhibiting the proportions of water, grain, composition, etc., of an English variety of wheat, has been copied for the purpose of comparison with wheat of New York growth. A comparison can be made by any person who feels an interest in this matter. I do not, therefore, propose to enter upon a detail of difference or similarity; observing, however, that in the statement respecting the phosphates and phosphoric acid, I have given the phosphates of the earths and phosphates of the alkalies, by which it will be perceived that the earths, the lime and magnesia, as well as iron, are in combination with phosphoric acid. This fact does not appear in the extract which is given.

The real composition of wheat appears only when an analysis is made of its parts, as bran (which is the cuticle), and its flour. Time, however, has not permitted me to make those analyses. I can, therefore, make only the following very brief statement:

Shorts, which is mostly a coarse bran, gives,

Ash	5·115 per centum, which contains
Silica	0·140
Phosphates of magnesia, lime and iron	2·380

Digitized by Google

Fine middlings lost in a water-bath..... 12.78 of water.
Bran..... 12.87 water.

Which proportions are rather greater than that given by wheat.

The specimen of winter wheat furnished by Mr. Peters... 9.72 water.
Summer wheat..... 9.62

Proportion of ash and water in straw of four varieties of wheat.

		Mineral matter in a ton of straw.
Indiana, water	3.50	
Ash	4.40	99.90 lbs.
Old red-chaff, water	7.50	
Ash	5.22	117.60
Improved white-flint, water	9.50	
Ash	4.50	160.80
Talavera, water	8.00	
Ash	5.46	122.80

STRUCTURE OF THE WHEAT GRAIN.

For all practical purposes, however, the grain may be said to consist of two parts only—the husk and the flour. The husk in grinding is separated from the body of the grain, and is called "*bran*," meaning that which is torn off or rent from the main body. The body of the grain after the husk has been removed, consists of a white, opaque, inodorous and tasteless mass, and may be regarded as a mass of starch.

If a grain of wheat is cut across through the middle, the "*husk*," "*bran*," or *outer skin* will appear as a narrow brownish line inclosing the entire mass—this skin bending inward forms the furrow which runs lengthwise on the grain. The hairy or tufted end of the grain is the upper or end opposite to that in which the embryo is enveloped. After having cut the grain across, if now a very thin slice cut in the same direction be placed under the microscope, the thin, brownish skin will be found to consist of three layers or rinds, like peels of an onion; the first of which is the outer skin (Fig.

Digitized by Google

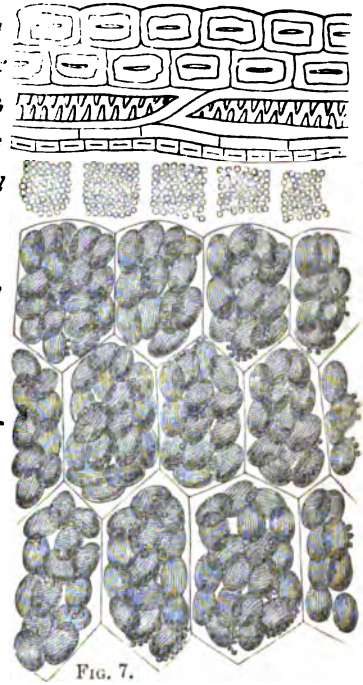


FIG. 7.

7), *a a*, consists of two layers of thick walled, porous cells, whose shortest diameter is thus exposed to view, the walls of which contain slight hollows or little canals. The middle layer *b* consists of cells similar to those of the first layer, but with this difference, namely: the cell walls are not so thick, and the pores are much more distinct than in the first: this layer has its longest axis at right angles to that of the first. The third layer is an exceedingly delicate and soft layer *c*, difficult to be properly defined with our ordinary microscopes, or described because of its indistinct definition. Immediately beneath this last described layer are the gluten cells (Fig. 7), *d*. The gluten in the cells appears to be a faint yellowish substance, very small grained, oily to the touch and smell. The cells in which it is formed are rather larger than any of the cells of the three layers just described, the walls of which are perhaps more delicate than of any others in the entire grain.

The entire portions just mentioned, and figured at *a a*, *b*, *c* and *d*, are the portions which before the recent inventions in milling machinery were considered as "bran."

Directly under the gluten cells *d*, lies the albuminous portion of the seed. This consists of hexagonal prismatic cells, which are filled with ovoid granules of starch "*e*." These

Digitized by Google

starch granules, *f*, Fig. 7, are enveloped in several layers of cellulose or cell membrane, which, when heated to excess in water, bursts and exudes the starch contained in them.

Wheat or flour is valuable just in proportion to the quantity of gluten it contains. In some varieties of wheat the gluten is more tough and fibrous than in others; flour dealers, but more particularly bakers, determine the quality of flour by making a paste of a small quantity of it, and the tenacity of the dough, or the length of "*thread*" to which the dough may be drawn, determines with them the value of the flour.

Several of the organic constituents of wheat may be obtained as follows:

Moisten a handful of wheat flour with sufficient water to form a stiff paste when triturated in a mortar; inclose it in a piece of thick linen, and knead it frequently, adding water as long as the liquid which runs through continues to have a milky appearance. After standing some time, a white powder will settle from the turbid water: this is *wheat starch.*

Starch is one of the principal constituents of flour, as indeed of all sorts of meal; the second constituent remains behind in the cloth, mixed with vegetable fiber, and is a viscous, tough, gray substance, which has received the name of *gluten* (vegetable fibrine). The gluten swells up only, in water without being completely dissolved; in its constitution it corresponds exactly with albumen, and, like it, contains nitrogen. When the water decanted from the starch is boiled, it becomes turbid, and when partially evaporated yields a flocculent or flaky precipitate; thus wheat meal contains also "*vegetable albumen.*" If this flocculent precipitate is separated by filtration or draining, and the clear liquid running through the filter on which the albumen is collected, is now evaporated to a thick sirup, the addition of alcohol will separate this sirupy residue into two parts—into gum, which is left insoluble behind, and into sugar, which dissolves in alcohol, from which it can be obtained in a solid form by

Digitized by Google

evaporation. Neither the gum nor sugar are thus obtained pure; both contain a small amount of saline matter, and the latter, besides, traces of fatty matters.

There is a certain intermixture of these organic substances — gluten, albumen, cellulose and starch — throughout the body of the seed, but are, notwithstanding, found greatly in excess in the parts indicated in Fig. 7.

The walls of the hexagonal or six-sided prismatic cells are composed of a material known to physiologists as cellulose; it is *always* an organic substance, and is distinguished by its insolubility in water, alcohol, ether, dilute alkalies, and acids. Vegetable wool, the pith of plants, and bleached paper, may be regarded as pure cellulose. Its chemical composition is the same as that of starch, namely: carbon twelve, hydrogen ten, oxygen ten parts.

Digitized by Google

CHAPTER VI.

GERMINATION OF THE WHEAT PLANT.

HAVING briefly explained the composition and illustrated the structure of the several parts of the wheat grain, the next important subject to be considered is the germination of the wheat plant. In all seed-bearing plants, germination is the first manifestation of vitality. This action invariably takes place whenever the necessary external conditions are sufficiently favorable; these conditions may be embraced in the following: a proper degree of heat or warmth, light, or rather *the effect* of light, or perhaps the vicinity of light, moisture, and access of atmospheric air. When seeds are so situated as to enjoy these four conditions in a proper degree, germination invariably takes place in the healthy seed, or seed in a normal condition. If a seed is so situated as to enjoy the proper effects of light, moisture and atmospheric air, but is yet deprived of all warmth, although it may not be really frozen, it will not—can not germinate. Water congeals at 32° to 31° Fahrenheit; a few degrees more of cold will burst stout glass bottles filled with water; by the action of frost, rocks are very frequently rent asunder, and it is related that at an armory in England, a cannon filled with water and the muzzle planted into the earth, was burst asunder by the action of frost, although the metal of the cannon was two inches thick. Quicksilver freezes at 40° below zero, Fahrenheit, or 72° below the freezing point, being a degree of cold which is met with only in such regions as those visited by the youthful and hardy, and much lamented Dr. E. K. Kane. The organism of the human system would be seriously affected under the influence of such a degree of cold, were the person not well protected by furs, fire, and other means. But the small seed

Digitized by Google

grain, less than a rain drop in size, which, judging from its delicate structure and tissues, as illustrated in figure 7, one would suppose that the first hard frost would burst the cell-walls and decompose the grain, as is not unfrequently the case with the flesh of potatoes and apples. But not so the wheat grain, it is tenacious of life, and yields its vitality only to an (artificial) cold of 58° below zero, or 90° below the freezing point!

The wheat grain is much more sensitive to heat than it is to cold. Almost all cultivable plants require a warmth varying from 50° to 70° Fahrenheit. All require a heat between 32° and 100°—under 32° none will germinate, above 100° all are destroyed. There are, however, exceptions to this general rule. Carpenter mentions a hot spring in the Manilla islands which raises the thermometer to 187°, and has plants flourishing in it and on its borders. In hot springs, near a river of Louisiana, of the temperature of from 122° to 145°, have been seen growing, not merely the lower and simpler plants, but shrubs and trees. In one of the Geysers of Iceland, which was hot enough to boil an egg in four minutes, a species of *chara* has been found growing and reproducing itself. One of the most remarkable facts on record, in reference to the power of vegetation to proceed under a high temperature, is related by Sir G. Staunton, in his account of Lord Macartney's embassy to China. At the island of Amsterdam a spring was found, the mud of which, far hotter than boiling water, gave birth to a species of Liverwort. A large squill bulb, which it was wished to dry and preserve, has been known to push up its stalk and leaves, when buried in sand kept up to a temperature much exceeding that of boiling water.

Plants require a certain amount of external heat, but the amount varies very much in different plants. Wheat will not mature at a lower temperature than 45°. Potatoes require 52°, barley 59°, while the larch pine can live when the thermometer is often, at mid-day, 40° below zero. On the other hand, the vine does not mature its fruit in Scotland; the In-

Digitized by Google

dian corn does not certainly ripen in England, and most of the Euphorbiaceæ can only exist in tropical climates. Members of the same species of plants attain different ages, chiefly in consequence of different amounts of heat which surrounds them. Wheat in Scotland lives one hundred and eighty days, at Truxillo one hundred, and at Venezuela only ninety. Some plants become annuals in this and other countries, while in their native habitats they enjoy a perennial existence. The croton oil plant is an example of the kind; in India it is perennial.

If a wheat grain be steeped, during fifteen minutes only, in water having a temperature of 122° Fahrenheit—a temperature but little above blood-heat—the germinating principle will be totally destroyed. In dry atmosphere the grain will, perhaps, endure a temperature of 170° Fahrenheit, without being seriously injured. This sensitiveness to heat may be the chief cause why wheat does not prove profitable as a crop in the tropics, where the heat of the soil frequently is found to be 190° Fahrenheit. Warmth, in a certain degree, is just as essential to the seed, in the process of germination, as it is to the egg during incubation, yet if the other agents or external conditions are not supplied, warmth alone will not cause the act of germination to be called into activity. If seeds can be so placed as not to be affected by the moisture, elevation of temperature will not excite the germinating powers; it is necessary to bear this fact in mind when packing seeds to be sent to California, or other tropical regions. As a general thing seeds are packed in cases, and these are stowed away in the hold of the ship, as soon as the tropics are reached the temperature of the cases is increased, this is attended by the formation of vapor from the moisture of the packages, and as a necessary consequence germination commences, but as there is nothing to maintain it, it ceases, and after germination once stops it can not again be excited to activity. There will be no risk attending the transportation of seeds if they are put in sacks, and kept in a place where the air can have free access to them.

Digitized by Google

Moisture is absolutely essential in germination, not only to promote it, but to maintain it when once called into action. The moisture penetrates the husk or outer covering of the wheat through pores or canals and ducts (see figure 7), and finds its way through the layers *a*, *b*, *c*, and *d*; when it reaches the starch cells *e*, it causes a great change to take place in the starch cells, which will be more fully explained. Although wheat and many other seeds will germinate when deposited on the surface of the soil; yet there is no doubt that they receive a better supply of moisture when covered with soil to the depth of about two inches. On the surface of the soil the seeds are not only more liable to be destroyed by insects, birds or small quadrupeds, but the direct rays of the sun seriously interfere with the supply of the requisite amount of moisture. Notwithstanding many eminent botanists declare that light is not only prejudicial, but that darkness is absolutely essential to consummate the act of germination, I have succeeded in germinating wheat and bunch beans on the surface of the soil covered with a pane of ordinary window glass, in about the same period that others germinated when regularly planted or sowed. Subsequent to these experiments I have learned that the Hon. Sidney Godolphin Osborne, of England, succeeded in growing the wheat plant to the length of two to three inches in glass jars on perforated plates of zinc suspended over water, in some cases with, and others without, soil, from which the plants were transplanted to glass tanks on the stage of the microscope in order to examine the process of development and growth.

Atmospheric air is absolutely necessary to germination; this air is composed of oxygen and nitrogen gas, while water is composed of oxygen and hydrogen gas. Notwithstanding almost all seeds will germinate in water, and none will germinate without it, yet they all require atmospheric air. No seeds will germinate in pure nitrogen, hydrogen, or carbonic gas; but all will readily do so in oxygen. The seeds of all aquatic plants germinate under water, and this circumstance might lead some to suppose that the presence of air was not

Digitized by Google

indispensable; but it must be remembered that there is no water—except when artificially rendered so—that is free from atmospheric air. The seeds of aquatic plants therefore germinate just like fish live in water, even though it is covered with ice, by virtue of the oxygen dissolved in it. It is said that Saussure failed to cause seeds to germinate in water which was boiled long enough to expel all the air from it.

The conclusion then is irresistible that air is indispensable to germination.

Experience has taught that from two to three inches is the proper depth to sow wheat. At this depth, in a properly prepared soil, it receives an abundant supply of moisture; is secured against the depredations of birds and insects; it is sufficiently in contact with the atmosphere, and receives the necessary influence from solar light and warmth. The following statement may be found in almost every agricultural journal, or treatise on agriculture; it purports to be an experiment by Petri, made half a century since, with wheat; but as Petri's experiment was with *rye*, and not wheat, it is probable that the experiment stated may not have been made by him, or else may not apply to wheat; certain it is that it was made in Europe and not in America:

Seeds sown to the depth of	Came above ground in	No. of plants that came up.
½ inch	11 days	7-8
1 "	12 "	all.
2 "	18 "	7-8
3 "	20 "	6-8
4 "	21 "	4-8
5 "	22 "	3-8
6 "	23 "	1-8

But I can not learn at what season of the year the experiment was made. This statement, then, is only of comparative value; it teaches that no more than 1-6 as many plants germinate at six inches depth as would at three inches. On the 3d day of October, 1857, I sowed some wheat on the surface of the soil, some at the depth of 1, 3, 4, and 7 inches. That on the surface and at 1 inch germinated and came above ground in six

Digitized by Google

days; at 3 inches in eight days; at 4 inches in ten days; at 7 inches in eighteen days. Unfortunately my arrangements to ascertain the proportion at each depth that came above ground of the whole number sowed, was interfered with, but there were two or three only out of a hundred at seven inches that came above ground, and they perished during the few cold days in November. My impression is that about three-fourths of that sowed at four inches came up; all of that at three inches, and all at one inch; all that on the surface not destroyed by birds germinated.

A German writer states that wheat sowed from one to four inches deep germinated the deeper the better, but from four to seven inches, the deeper the less successful was germination; at eight inches the seed did not germinate at all. It is reasonable to suppose that at the depth of eight inches it was deprived of the proper supply of oxygen gas, or rather atmospheric air. The warmer the air and the soil are, the sooner will germination be consummated. In Sweden, wheat sown on the 28th of April required eighteen days to come above ground; that sown on the 21st of May required eight days only; while that sown on the 4th of June required no more than six days.

Light certainly is an indispensable agent in exciting into activity the germinating principle, as is abundantly proved by the following experiment and discovery of Mr. Robert Hunt, author of "*Researches on Light:*" "Some seeds being placed in the soil, in every respect in their natural conditions, duly supplied with moisture, and a uniform and proper temperature maintained, we placed above the soil a yellow colored glass, a cobalt blue glass, and a glass colored deep blood red, and allowed one portion to be exposed to all the ordinary influences of the solar rays. The result will be, that the seeds under the blue glass will germinate long before those which are exposed to the combined influences of the sunshine; a few of the seeds will struggle into day under the red glass, but the process of germination is entirely choked under the yellow glass."

Digitized by Google

EDINBURGH, 1, GEORGE THE FOURTH'S BRIDGE,
September 8, 1853.

My Dear Sir:—I am favored with yours of the 5th, relative to my practical experience in the effect of the chemical agency of colored media on the germination of seeds and the growth of plants.

I must first explain that it is our practice to test the germinating powers of all seeds which come into our warehouses before we send them out for sale; and, of course, it is an object to discover, with as little delay as possible, the extent that the vital principle is active, as the value comes to be depreciated in the ratio it is found to be dormant. For instance, if we sow 100 seeds of any sort, and the whole germinate, the seed will be the highest current value; but if only 90 germinate, its value is 10 per cent. less; if 80, then its value falls 20 per cent.

I merely give this detail to show the practical value of this test, and the influence it exerts on the fluctuation of prices.

Our usual plan formerly was to sow the seeds to be tested in a hot-bed or frame, and then watch the progress, and note the result. It was usually from eight to fourteen days before we were in a condition to decide on the commercial value of the seed under trial.

My attention was, however, directed to your excellent work, "On the Practical Phenomena of Nature," about five years ago, and I resolved to put your theory to a practical test. I accordingly had a case made, the sides of which were formed of glass colored blue or indigo, which case I attached to a small gas stove for engendering heat; in the case shelves were fixed in the inside, on which were placed small pots wherein the seeds to be tested were sown.

The results were all that could be looked for: the seeds freely germinated in from two to five days only, instead of from eight to fourteen days as before.

I have not carried our experiments beyond the germination

Digitized by Google

of seeds, so that I can not afford practical information as to the effect of other rays on the after culture of plants.

I have, however, made some trials with the yellow ray in preventing the germination of seeds, which have been successful; and I have always found the violet ray prejudicial to the growth of the plant after germination.

I remain, my dear Sir,

Very faithfully yours,

CHARLES LAWSON.

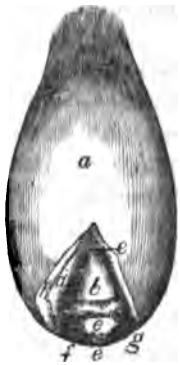


FIG. 10.

If we place a grain of wheat on the table with the "*furrowed*" side down, and the "*hairy*" end to the left, we will find concealed under the two thin skins, *a a*, fig. 7, at the right end of the grain, and under a little depression or shield, the embryo, *e*, fig. 10. The perisperm or albuminous body *a* is the storehouse containing the nourishment for the embryo; during the process of germination the roots proceed downward from the radicle "*c*," and the stalk or halm upward from the plumule or feather "*b*." As soon as moisture has found its way through the canals in the husks or skins (*a*, *a*, and layers *b*, *c*, and *d*, fig. 7), so as to be in contact with the starch cells *e*, fig. 7, the moisture or water penetrates the cell-walls of the seed and its embryo, and there forms a strong solution. The seed has now the power of decomposing water—the oxygen combines with some of the carbon of the seed and is expelled as carbonic

FIG. 10.—Grain of wheat (magnified) showing the embryo.

a. Amylaceous body.

b. plumule.

c. radicle.

b. and *d*. first and second seed-skins.

e. prominence from which the main root issues.

f. and *g*. prominences from which issue the true roots.

Digitized by Google

acid. The presence of moisture and oxygen induces putrefaction of a portion of the albuminous matter in the cells; this putrescent matter becomes an actual ferment—exhales carbonic acid gas, generates heat and converts the insoluble starch stored up in the cells into soluble sugar—the whole remaining albuminous matter is speedily rendered soluble. The cells, instead of starch, are now filled with a strong solution of sugar, albumen and salts. The cells become more distended and those of the embryo having been stimulated into action are being developed according to the laws of vitality with which they were impressed at their formation.

The substances deposited within the seed, that is the starch, cell-walls or cell-membrane (cellulose), were undoubtedly designed to furnish food to the young plant until it can provide for itself, for it is nevertheless true that the young plant, like the young babe, is dependent for its nourishment upon the bosom of the parent that bore it, and requires during childhood a different food from that in maturity. In wheat, starch is the most important ingredient of this food; but as starch is insoluble in cold water, it could not unaided attain the proper degree of fluidity, to be transferred from the albuminous body to the embryo. It has been observed that when moisture acts on the albuminous body of the seed, that carbonic acid is evolved: this evolution causes in some manner as yet unknown to scientific investigations, the formation of a substance known as *diastase*. The diastase is allied in its general properties to gluten, and converts the starch of seeds into gum and sugar for the nutrition of the embryo.

Most persons are familiar with the process of malting barley. Barley is soaked until it has absorbed about one-half its weight of water, the grain is then thrown upon the malt floor, where it is kept in a heap in a layer about a foot thick. While in this condition the process of germination soon commences, and much heat is developed, which in a short time would destroy the grain were it not now spread out into thinner layers. When the young shoot on these grains of barley has

Digitized by Google

attained the length of the grain itself, then the germinating process is terminated by removing the barley to a kiln heated nearly to blood-heat. Every one knows how sweet and mucilaginous malt is to the taste; in malt the starch of the barley has been changed into sugar by the formation of diastase, which latter, according to Persoz, does not exceed the one five-hundredth part of the malt, but notwithstanding this quantity, Liebig says that the amount of diastase contained in one pound of malt is capable of converting five pounds of starch into sugar; and that one part of diastase will convert 2000 parts of starch into dextrine and sugar. The experiments made by Guerin, to determine the influence of temperature upon the action of diastase are exceedingly interesting. He found that 77.64 per cent. of sugar, and 12.25 of diastase were produced from 100 parts of starch paste at the temperature of 68°. The paste was liquefied, and 12 per cent. of sugar produced in it at 32°, or freezing point; although the parts were liquefied by diastase at the temperature of 15 to 20°, dextrine only, and no sugar was the result. This fact offers one explanation why plants can not grow at a low temperature, namely, the starch of the seed can not be converted into sugar, and the plant is thus left destitute of the essential aliment of growth.

If a paste be made by boiling starch with water, and while it is yet hot, we add (in a saucer), say twenty drops of sulphuric acid, with constant stirring; then place the saucer on a steam-bath till the paste has become semi-transparent and liquid; then add prepared chalk till there is no more acid reaction—this chalk has a great affinity for the acid, and with it forms plaster of Paris or gypsum—after having filtered the mass from the gypsum, leave the former to evaporate in a warm place. The residue is a GUM *perfectly soluble in water.* As starch digested with sulphuric acid forms dextrine or gum and becomes soluble in water, may not the evolution of carbonic acid in germination perform the same office?

If we boil, say about two and a half ounces of water, and add to it twenty drops of sulphuric acid, and then add one

Digitized by Google

ounce of starch in the form of a paste, but in small quantities at a time so that the boiling may not be interrupted; when all the starch has been added let the mixture boil for some moments, then neutralize the acid by chalk as in the preceding experiment, and evaporate the liquid to a thick sirup; this sirup is starch sirup, and consists of a solution of sugar and water, from which a beautiful article of solid white sugar may be prepared. In neither of these experiments has any portion of the sulphuric acid been decomposed, neither has any of it combined with the organic substance, because, in the gypsum thus artificially formed, we obtain precisely the same quantity of sulphuric acid that had originally been employed.

Make a paste of a quarter of an ounce of starch and two ounces of water, add to this (by rubbing) diastase equal to one-fourth the paste, submit it to a temperature not exceeding 150 ° Fah., till the paste is formed into a thin transparent liquid—boil this mixture for some time—then strain through a cloth, and evaporate in a warm place. The mass is dextrine or gum, soluble in water like that formed in the first experiment, or like that formed in the germinating wheat grain.

Repeat this process, with this difference, that is, take three times the amount of diastase that was employed in the last experiment, but prolong the heating to several hours, but be careful that the heat does not exceed 170 ° Fah. This process produces, like the last, dextrine, but by boiling this is soon changed into starch sirup as in the second experiment, from which starch sugar may be obtained.

Notwithstanding, we can not observe the changes while they are taking place in the wheat grain, as well as we can in the artificial processes with starch just enumerated; yet there is no doubt that in its turn the imbibition or sucking up of moisture and absorption of oxygen causes the liberation of carbonic acid gas, the formation of diastase which causes the conversion of starch into dextrine, and the dextrine into starch sirup. This starch sirup or sugar is what the young plant

Digitized by Google

feeds upon. That this is really the case is proved by the following observation stated by Henfrey:

"The cell-walls are formed of a modification of the compound of which all vegetable cell-membranes are formed. Within the cells exists nitrogenous matter in the condition of protoplasm, that is, a tough mucilaginous fluid, colorless, or with a yellow tinge, and frequently of more or less granular character, which increases with the age of the cell. The increase of the plant is dependent on the assimilation of substances requisite for the production of new cell-membranes, and of other substances to furnish new nitrogenous contents. When no material for forming cellulose exists, the plant can not grow; but in solution of pure sugar, in the absence of any nitrogenous substance, the plant will multiply its cells for a certain time, the protoplasm of the old cells being transferred into the new ones as they are successively evolved. But under these latter circumstances the cells become gradually smaller, and at length cease to multiply; a portion of the nitrogenous matter being *wasted* in the reproduction, till it becomes insufficient to carry on the growth; but just as soon as nitrogenous matter is added, which can be assimilated to form cell-membrane, the growth (fermentation) goes on."

Diastase then converts the entire contents of the seed into a tough, mucilaginous sirupy mass, which forms the food or cell-contents and cell-membrane for the young plant, till it can assimilate nourishment from the soil. In germination diastase is formed in the neighborhood of the embryo, but not in the body of the mass of the wheat grain.

I have no data from which to determine accurately how long the contents of a seed will nourish the young plant. On the 25th of December, 1857, no trace of starch, or starch sirup in the wheat grains that were sown on the 3rd of October, could be found, although it was tolerably abundant during November. Herman Wagner states that on the 1st of July all the amylaceous (starch) substances had disappeared from a barley grain that was sown on the 15th of May.

Digitized by Google

Gum, and dextrine were mentioned as being synonymous terms, I did so in order to convey to the non-scientific reader a clearer idea of the matter under discussion; but every chemist is well aware that the most important difference exists between vegetable gum and dextrine, namely, dextrine is susceptible of being converted into grape sugar by sulphuric acid or diastase, while gum is incapable of undergoing any such change. In the animal economy dextrine may very appropriately be classed with those substances which enter into the blood; the gastric juice converts all the starch received into the stomach into dextrine. Gum, on the other hand, is not taken up into the circulation, and is apparently of very little importance as an article of food, although its chemical constitution is isomeric, that is, it is composed of precisely the same elements, and in the same proportion, as starch and dextrine, namely:

	Carbon.	Hydrogen.	Oxygen.	
Starch	12	10	10	Lœwig.
Dextrine	12	10	10	"
Gum	12	10	10	"
Gluten	12	10	10	
Cellulose	24	21	21	Encyclopedia.
Cane Sugar	12	10	10	plus H. O. Lœwig.
Grape Sugar	12	12	12	plus 2 H. O.

Having stated thus much of the chemical process of germination, it may not be inappropriate to mention that many physiologists regard the process of germination as being a process of combustion or slow burning. They have been led to make such an inference from the fact that oxygen is absorbed and carbonic acid gas evolved or exhaled; but the experiments of De Saussure are direct evidence that the amount of carbonic acid given out is in proportion to the mass and not the number of seeds, proving that the carbonic acid is produced from the decomposition of the starch as a chemical process, and not from the growth of the embryo as a process of life. It is further proved that the relation be-

Digitized by Google

tween the oxygen consumed and the carbonic acid evolved is not the same in all plants, but these proportions should be constant if the theory of combustion is correct. Boussingalt discovered that the processes were in activity in the albuminous body after germination has taken place, and the young plant capable by its development of radical, or root and plumule, or young stalk, of an independent existence, which were supposed to be peculiar to that process only.

On the 24th of June, 1856, Hon. Sidney Godolphin Osborne read a paper before the London Microscopical Society, on "Vegetable cell-structure and its formations, as seen in the early stages of the growth of the wheat plant," in which many new facts in relation to the germination of wheat are stated. Mr. Osborne contrived to have wheat grains germinating on the stage of the microscope, and by this means was enabled to observe every change which took place.

The first symptom of germination in a seed of wheat consists in the liberating from its surface a species of filamentous or threadlike network, somewhat similar to the mycelium or roots of many of the fungi (toadstools, mold or mushrooms) which infest vegetables; nearly at the same time the whole seed is seen to swell, and become as to its external covering transparent. At the germinating point of the seed there now appears a very small wart-like projection of tough white matter; this puts forth one cone of the same substance, pointing upward—the future plumule; and several others projected in a straight line, soon to curve downward and become the roots, Fig. 8. These cones of protruded substance soon burst their outer cell-texture (*h*.) At this early stage a root cone becomes a very interesting object under a high power of the microscope. At its apex (E E E, Fig. 8) there are what may with propriety be termed free capsules of cells, somewhat lozenge or diamond-shaped at extremity, *b*, *c*, Fig. 9, but becoming longer and more narrow toward the base. This free capsule envelopes the inner apex of the growing root, but there is a clear cell-less space between its base and the part

Digitized by Google

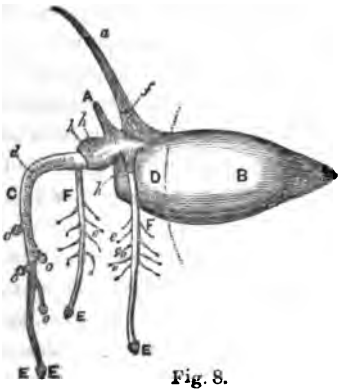


Fig. 8.

of the apex which it there covers. Beneath this cellulated cone or capsule, the growth of the root takes place, by the development of cells at the extremity of the inner apex of the root. At a certain period of growth every root puts forth rootlets or suckers *e e*, Fig. 8. These consist of long, narrow, cell-like structures which put forth from the region of the fibro-vascular bundles of the main root.

In order to determine the function of the capsule (Fig. 9), Mr. Osborne grew wheat roots in distilled water, in a solution of alum, in spring water colored with carmine, with vermillion and indigo. He treated the waters in which they were growing with various fertilizing matters; he succeeded in growing a wheat plant so as to produce a foliage of fourteen inches in length in a strong solution of prussic acid and cyanide of potassium. From these experiments he concludes that the epidermic plasm does absorb moisture from the soil; in fact, it requires moisture to preserve its elasticity, combining in the formative matter it secretes some of the matters presented

FIG. 8.—A grain of germinating wheat magnified.

A. Cellular tissue, the original covering of embryo blade.

B. Seed, starch, gluten, etc. [amylaceous body].

C. Main root.

D. Hard Cellular matter, the base of growth of root and stem.

E. E. E. Free cones of cells at the points of roots.

F. F. Lateral roots.

a. Plumule—future stalk.

d. Course of bundle of dotted fiber.

e. *e*. *e*. Suckers.

f. Course of spiral fiber.

h. *h*. *h*. Cellular tissue, original covering of the embryo root.

Digitized by Google

to it, in whatever medium it may grow, still the great sources of plant, health and strength are obtained by means of the capsules or spongioles, the *terminus* of every root and rootlet, and also by the absorbent cells ever found at the extremities of the numberless suckers; for it is at these points that he found the cell structure ever greedily taking in whatever of foreign matter he succeeded in introducing into the *media* in which the plants were grown. There can be no doubt that the plant requires not only certain chemical constituents to secure its health, but that these must be offered to it, when growing in a medium, allowing the utmost freedom to the capsules of the roots, rootlets and suckers. There is no doubt that a highly pulverized poor soil would grow better plants than a close, hard, tenacious soil, however fertilized. When it is considered what a wheat root has to do, how it has to force its way and introduce its lateral branches through all manner of crevices, and among all kinds of material in the soil, we are struck with wonder at the beauty of the contrivances by which the spongioles or capsules, constructed of highly elastic material, can float their onward way; consolidating as they grow, and having within them the growing organism of a scaffolding sufficiently strong to bear up in its deposited order, all the necessary structure in any course it may be compelled to take, however tortuous.

There is a "circulation" in every one of the long suckers put forth from the roots, which can be plainly seen along the outer edge of each sucker, running from the root toward the blunt point, but no current has yet been traced returning toward the root.

In order to ascertain whether the roots of the wheat plant take in nourishment for the plant, from the medium in which they grow by means of their capsules and those on their rootlets, Mr. Osborne made the following experiment: "Wishing to make some experiments on the action of poisons, I grew a small crop in a strong solution of prussic acid, with cyanuret of potash added to it—this gave a very vigorous growth to

Digitized by Google

roots and leaves. Just as the root had acquired about four inches of length I applied my coloring matter to the fluid in which they grew; I wished to see whether this would be taken up any where but at the point of attachment of the capsules to the apex of the root. The result is that it was not; the parenchyma or outer cell-texture is colorless; that the capsule cells are strongly painted; that as they have pushed on, nothing has been left in the natural cells colored but very small nuclei, excepting only along the whole course of the vascular bundle; here, what I call the pith tubes, were seen to have imbibed the pigment, and it can be traced along their whole course, *i. e.*, along the whole course of the growth made since the solution was colored."

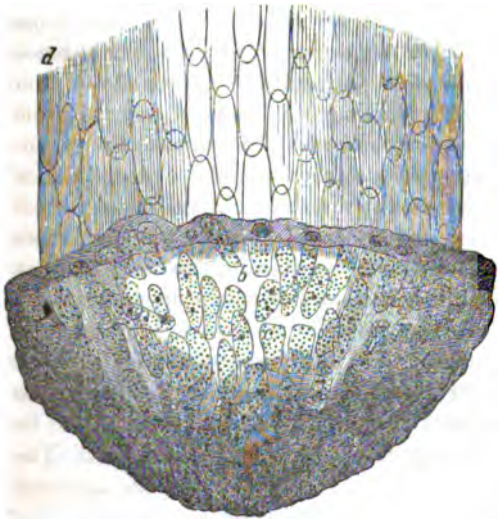


Fig. 9.
Spongiole, or free cone of root E.

There is a physiological phenomenon connected with the growth of roots, which was omitted in the proper place; namely, shortly after the radicle C, Figure 8, has burst through the integument lateral roots F F, also developed on both sides of the main root. The main root "C," Fig. 8, dies away soon after the lateral roots F F, are developed sufficiently to elaborate nutriment from the soil, or media in which they are growing, and are developed from the protuberances *f*, *g*, Fig. 10, which may distinctly be traced in the embryo.

Digitized by Google

They are in immediate connection or communication with the base of the first leaves. These lateral roots in their young state prove to be sheaths only (*h h h*, Fig. 8), from which at a later period the true roots F F, protrude. This method of root growth is characteristic of and peculiar to the cereal plants, and is by botanists designated as *endorrhizal.*

There is no subject connected with vegetable physiology which more nearly concerns the practical cultivator, as well as the man of science, than the precise nature of the *action of roots;* for on them more than on any other organ of a plant depends the health of crops of every kind, without one single exception. That the subject has not received more attention is one of the curiosities of science. It is true there are many statements of variable character and value, yet even more speculations respecting the manner in which roots behave—theories of excretion—assertions regarding the chemical action roots are said to exercise on dead matter; but the quiet practical man who reads these beyond the atmosphere of science, is far from being satisfied with what he finds in books.

The question as to whether the roots of plants are or not endowed with any special excretory functions is one which has occupied the attention of many naturalists, as being one of considerable importance as well to the vegetable physiologist as to the agriculturist in its application to the principles of alternation of crops. No absolute conclusion has as yet been come to, the affirmative as well as the negative having been respectively maintained, either from general induction, or more rarely from direct observation and experiment. The opinion, however, that no such excretions take place has been the most generally adopted.

The impossibility of closely following under the microscope, in their natural circumstances, vegetable phenomena which take place under ground, and consequently in the dark, and in an opaque medium, is obvious. As a nearest approach to it, Gasparrini has caused the seeds of various plants to germinate under glass, in water, or in well-washed sand, in the

Digitized by Google

dark or under diffused light, and thus examined their roots without disturbance in various stages, and at various seasons. He also raised plants for the purpose in vases of sand well pulverized and washed, so as to be able to free the roots for examination at a more advanced period with the least possible injury. His numerous experiments appear to have been conducted with the most scrupulous care, for which, moreover, his well known success in analogous researches offers a sufficient guarantee.

It has long been known that roots absorb the nutriment necessary for the plant, by means of the young fibers which form the ultimate ramifications of the roots; that these fibers are terminated by a short portion of a loose and soft texture called by botanists the spongiole, Fig. 9; that this spongiole is the point of growth of the fiber, usually bearing at its extremity a kind of cap of a harder and drier texture, called the pileorhiza, *a*, Fig. 9, which is pushed forward by the fiber as it grows; and that, immediately below the spongiole, the fiber is usually more or less invested with a short down consisting of small spreading hairs. Gasparrini shows that the spongiole itself seldom takes any part in the absorption of the nutriment for the plant, but is nothing more than the young as yet imperfect part of the fiber, consisting of cellular tissue in the course of formation; that the pileorhiza is a portion of the epidermis or covering of the fiber which, after a period of comparative rest, is torn from the remainder of the epidermis and pushed forward by the growth of the spongiole under it, and is ultimately cast off to be reproduced by similar causes the following season; and that in the great majority of vascular plants the nutriment is either entirely or chiefly absorbed by the root hairs formed on the young fibers at the base of the spongiole, and which he on that account denominates suckers.

Each of these root hairs or suckers consists of a sub-cuticular cellule of the epidermis, more or less lengthened out into a cylindrical hair-like form. It is at first uniformly smooth and straight, but at a later period either the extremity or the

Digitized by Google

upper portion or rarely nearly the whole length becomes variously deformed by club-shaped dilations, or irregular ramifications. The length of the suckers, and the shapes of these irregularities, are often more or less affected by the obstacles they meet with in the earth, but not entirely so, for when grown in water perfectly free from an impediment there is very great irregularity in both respects. Internally, however much ramified, the cell remains entire with one continuous cavity from the base to the extremity of all its branches. Its walls also consist of a single membrane, no chemical reagent having disclosed any distinction between the walls of the cell and an external cuticle.

These suckers appear to absorb the alimentary juices by endosmose over their whole surface. Like leaves on the young aerial shoots, they are formed on the young shoots of the roots; like leaves also they die and disappear after a longer or shorter season, leaving the old roots entirely without them.

When fully formed, and before they decay, these suckers become more or less covered in their irregular branching portion (rarely in their basal cylindrical part), with viscous papillæ or adhesive globules, forming granular masses, to which the surrounding earthy particles strongly adhere. Are these viscous masses excretions from the roots, or are they the residue of substances contained in the earth and chemically decomposed by the roots in the absorption of such elements only as might be suited for the nutriment of the plant? It is to the solution of this question that Gasparrini's experiments are chiefly directed, and he concludes that they are entirely exuded from the suckers.

In the first place he adduces several experiments in refutation of those who believe that the tender fibers of roots possess some chemically dissolvent properties, and that it is by such means that they are enabled to penetrate into masses of hard substances, whether inorganic or organic, such as the woody tissue of living plants. In the case of the common Mistletoe growing on a Pear-tree, he followed the radical fibers

Digitized by Google

of the parasite from the woody tissue through the alburnum and the parenchyma of the bark sometimes to the length of half an inch. They could be clearly traced their whole length, although forming an intimate cohesion with the tissue of the matrix, except the spongiole at the extremity, which was always free; but he never saw the slightest indication of any morbid alteration in the tissue thus penetrated.

In the case of the young plants of wheat, rye, barley, rapeseed, and others which had been caused to germinate under glass, the process of excretion was readily observed. Previous to the formation of the adhesive globules on the surface the suckers were full of a fluid in which floated a granular substance showing clearly a circulation in two currents, the one ascending, the other descending; after a time the suckers opened at the extremity and discharged the greater part of the granular substance they contained, the discharge being preceded by a peculiar motion analogous to that of pollen grains before they burst. The contact of a drop of warm water accelerated the discharge, and if the fiber was cut through at its base the motion of the sucker was sudden and convulsive, and the contents discharged with considerable elasticity.

In the roots grown naturally within the earth, the circulation of the fluid contents of the suckers, when observed, was slow and feeble. Those which yet retained the granular substance withinside were as yet free from the external papillæ, while those covered with the viscous masses outside were nearly empty internally, but in these cases the excretion appeared but rarely to have been effected by the bursting of the extremity, but usually by exudation, through the membrane forming the walls of the cavity, and that in a manner which could scarcely be explained by endosmose alone, but by some other force unknown to us, and which must be included in the mysteries of vital action.

With regard to the effects produced by these exudations on the capabilities of the soil for the nutriment of other plants at the same time, or in succession, there is nothing to show

Digitized by Google

that they possess any acid, caustic, or saline properties likely to act prejudicially on other roots. Whether the matter be compared to the fecal excretions or to the residue left by insensible perspiration on the skin of animals, it can well be imagined that it can not serve for nutriment if reabsorbed by the same plants, nor probably if absorbed by others until decomposed, but owing to its extreme tenuity the decomposition takes place very readily, and as recent detritus of vegetable matter, its quantity is very small in comparison to that of the decayed sucker and pileorhizas, and of the numerous fibers which perish from natural or accidental causes. If in the relative effect of different plants on the impoverishment of the soil the radical excretions have any effect, it can only be caused by the difference in the quality left in the soil by different species. Some of the plants known to exhaust the soil in the highest degree, such as Flax and Box, have few or no suckers to their roots and leave scarce any exudations. Rye and many other Grasses deposit very little in comparison with Crucifers and Cichoraceæ. Hemp on the other hand, which is a great exhauster, exudes a great deal by the roots; so do Wheat and Barley, but the exhausting effects of these plants may be traced to other causes. Thus, then, although from these experiments the fact of absorption and excretion from the surface of organs of temporary duration on the young shoots of roots is clearly demonstrated, we do not possess any data sufficient to affirm that the matter excreted produces any effect whatever on the capability of the soil to supply nutriment to other plants grown in it.

One of the experiments made by Gasparrini is very instructive as to the noxious effects of vegetable manures in those first stages of decomposition which are so favorable to the development of molds. In the month of January he sowed seeds of *Triticum spelta*, or as it is more commonly called *Spelts*, in a number of small garden pots filled with well washed Vesuvian sand. In one pot he placed a piece of young dead wood of Ailanthus glandulosus, in another a piece of bread, in

Digitized by Google

another a portion of a green potato, in a fourth a portion of a radish-root, in a fifth some parings of kid's hoofs and bits of nutshells, in the sixth nothing, for the sake of comparison. The pots were all watered with common drinking water, exposed by day to diffused light, and in clear days for a few hours to the direct light of the sun, and placed under cover by night. At the end of a month each pot contained three plants, all, even those in the pot without any organic substance, equally healthy and luxuriant, about a span high, and with two leaves each.

In the pot in which was the piece of bread, the roots of the spelt were much branched, the fibers almost all turned toward the sides of the pot; the numerous suckers were as yet scarcely modified, or had only slight gibbosities toward the extremity, no circulation was perceptible, the granular mucous substance inside was more or less abundant, and many were sprinkled externally toward the extremity with similar mucous granular masses. A few fibers approached within a certain distance of the bread, but none had penetrated within it. The bread had become a soft, putrid, spongy mass, covered externally with white branching filaments spreading from it into the sand in every direction, and already in many places having nearly reached the sides of the pot, and here and there a commencement of fructification seemed to show that these filaments belonged to a species of *Botrytis*. The spongy mass of the bread was also almost entirely occupied by a violet colored mycelium which appeared to be that of a *Penicillium;* the filaments of this mycelium had also spread from the bread in various directions. Some had descended to the bottom of the pot, where they had attacked and produced a morbid alteration on one side of a bit of the rhizome of *Smilax aspera*, which had been placed over the hole of the pot. In another direction the mycelium of this *Penicillium* together with a few filaments from the *Botrytis*, had reached a fiber of the *Triticum*, had encircled it for the length of half an inch. The portion of fiber so attacked was soft, livid and

Digitized by Google

dead; and the extremity toward the spongiole was shriveled and also dead. In the livid portion the suckers were but little developed and mixed with the *Botrytis* filaments; but it was evident that the chief injury to the roots was produced by the *Penicillium*, whose filaments adhered firmly to their epidermis. In none of the other pots had the roots of the Spelt come into contact with the organic substances deposited in the soil.

PLUMULE.

Having thus briefly described the process of germination, and the formation, function, and growth of the roots, the plumule or future stalk next merits attention. A section made with care through the white substance, from which the plumule and roots protrude, gives a beautiful view of the early formation of the plumule. Several layers of an oval-headed cell structure are seen, one longer than the other, *i. e.* more advanced in growth, the shortest or youngest being very small. When detached from each other their outline is that of a blunt spear head (Fig. 11, A,) at this stage their substance consists of a cellular texture of which the cells are very small as to their actual area, with rather thick walls of plasm. Toward their base, in the center of each, is the well defined indication of an upward line of spiral fiber—these are the embryo leaves. They have the same epidermic plasm as

FIG. 11.*

* FIG. 11. Young stalk of wheat (the extreme point of *a*, Fig. 8, magnified); it is seen to possess free capsule of cells and epidermic plasm, closely identical with those of the root.

Digitized by Google

the roots, and into it are seen to project small points, the future hairs on the leaf of the plant. They have capsules, so far as yet can be determined, identical in structure with those of the root, although adhering more closely to the substance covered, and the component cells do not separate in the way they do in that part of the plant. As the young leaves prepare to enter the outer world, they fold themselves longitudinally into a very small compass, Fig. 11, A, and carry on with them, until they have obtained an inch or so of growth, a straw-colored cellular envelop of stout texture, Fig. 11, A, B, (Fig. 12, a portion of the same highly magnified), this appears intended to protect them as they force their way through the soil, and on their first exposure to the weather in the outer world. At this stage of growth chlorophyll or green coloring matter is found existing in the leaves.

There can be no reasonable doubt that the cellular envelop A, B performs a similar function to the capsules of the roots Fig. 9, that is, it exerts a chemical influence on the soil which lies immediately above it, rendering the soil exceedingly pliable, so much so that the tender plumule can readily penetrate it. The writer remembers having seen the young wheat plant force its way from a depth of several inches, through a compact clay soil over which a farm wagon had passed so often as quite to obliterate all the traces left by the plow or harrow.

Fig. 12.*

As soon as the plumule has penetrated through the soil an inch or more, it then gives birth to the first true leaves, while the central bud is destined to become the future stalk. The first experiment of the young plant is to form a joint or knot

* Fig. 12. A portion of (Fig. 11, from A to B) the edge of the young leaf of wheat, highly magnified.

Digitized by Google

immediately beneath the surface of the soil, and another one just above it. The upper one of these two joints or knots is the true commencement of the stalk; the joint immediately beneath the soil becomes the point from which emanate the so-called crown-roots, and which are the chief laboratory for the preparation and distribution of the future nourishment of the plant.

The plumule is of great importance to the existence of the plant, and by it may be readily demonstrated how dependent each organ of a plant is on the other, and how harmoniously the whole silently performs its destined function. If the "*heart*" or plumule of the wheat plant is pulled out, it will not be replaced by a new one, as is a spider's leg or snail's head; but the plant will form a new shoot and put forth a new plumule. If, however, *all* the plumules are pulled out of a bunch or multiplied wheat stalk in the spring-time, the plant will die, from the fact that the dotted cell-tissue, Fig. 8, *d* and *f*, from which both the roots and plumule grow, will have been severed; this cell tissue appears to be as important to the vitality of the plant as is the spinal marrow in the animal kingdom. If a section is carefully made through this substance, in a direction which will include the lower part of the plumule and the commencement of the roots, we get a view of the basis of the whole vascular system. A large number of pitted cells are seen, some passing downward to branch out into bundles, one to every root; others branching upward to the leaves.

Having stated the composition and structure of the wheat grain, as well as both the chemical and mechanical changes which take place during the process of germination, it may not be irrelevent to recapitulate the principal phenomena.

The seed, when planted in the earth, was to all appearances an inert, inodorous, and tasteless mass. In a short time it presented unmistakable manifestations of vitality, in the development of plumule and radicle; as soon as the latter made their appearance, it was demonstrated that the starch, which is

Digitized by Google

insoluble in water, had become solvent, and was converted first into gum and then into sugar to feed the young germ; the cell walls of the hexagonal prisms were dissolved to form new cell walls in the plumule and radicle.

As grain after grain of starch in the immediate vicinity of the plumule was converted into sugar, or rather a step beyond, for the nourishment of the plumule, the cells in the central and posterior portion of the grain were also undergoing the fermentative process, and as fast as required, the pabulum, undoubtedly impelled by chemical or electrical affinity, finds its way to the new plant. In the course of fifteen or twenty days, the entire store of food contained in the starch will have disappeared, and the young plant is now ready to enter upon the "trials of life" upon its own account, and in the very out-set the young roots find, that like the genus homo, "they are obliged to labor for their bread."

It will now be necessary to give a brief description of the elements by which the rootlets are surrounded, and from what substances and in what manner they derive their nourishment. The nutrition of plants involves within its province the entire field of Scientific Agriculture, but in this essay it is proposed to discuss that which relates to the cereals only, and taking wheat as the generic type.

Digitized by Google

CHAPTER VII.

ORIGIN AND CONSTITUENTS OF SOILS.

So LONG as the young plant had in store organic materia which was provided for its growth by the parent plant, so long were all its energies and capacities not fully called into action; but, with the disappearance of the last granule of mother starch, the plant finds itself compelled to elaborate and assimilate elements from the inorganic substances by which it is surrounded, or perish. The first inorganic substance with which it comes in contact in its first search for food, is in all probability clay. What qualities has inorganic clay in common with organic starch; what does it contain that the tender rootlet can elaborate and assimilate so as to form from it not only materials for new walls or cells, but materials to fill the cells, material to form the sharp leaf, the firm stalk, the circulating sap, the head with its wonderful structure of chaff, beards, and young grains of wheat? It may be argued that the wheat plant derives its nourishment from the organic manure which the prudent farmer has committed to the bosom of the earth; but suppose reference is made to a crop of wheat on new and virgin soil, on which no manure has been placed? In such a case, replies another the nourishment may be derived from decaying vegetable matter. Were it not for the patient investigation of physiologists, the last named position might be assumed as the true one, but experiments have demonstrated that plants can be grown to full and perfect maturity without a single particle of organic matter.* If

* TULL'S System of Culture, as also the more recent LOIS-WEEDON System, as well as facts developed by underdraining, incontestably establish the fact that as good crops can be grown without as with organic manure.

Digitized by Google

plants did not assimilate inorganic matter, there would be no ashes left after burning them; these ashes, as was demonstrated on a preceding page, consist entirely of inorganic substances.

Much of the qualities as well as of the constituents of clay may be determined by tracing it to its origin. Possibly it may cause a little surprise to state that the soft and plastic *clay* is derived from GRANITE, which is proverbial for its unyielding hardness and firmness.

Granite is composed of three and sometimes four distinct substances, namely: a white lustrous mineral named *feldspar;* a white, generally opaque, one, known as *quartz*, and one whose luster is more or less pearly, and color varying from a transparent white to a dark olive green, and is susceptible of being divided into thin flexible laminæ; this latter is known as *mica*; and a dark bottle-green mineral, known as *hornblende.* With the exception of quartz and oxide of iron, feldspar is the most generally diffused mineral. Klaproth made an analysis of it and found it to consist of—

Silica	64.50
Alumina	19.75
Potassa	11.50
Oxide of Iron	1.75
Water	.75
Lime	a trace.
	98.25

Quartz is nearly pure silicic acid. The fine white sand found in the beds of streams is quartz; that which is whitest is the purest; many sandstones are nearly pure quartz, but more generally are mixed with oxide of iron, lime, etc. Flint and rock crystal are quartz, the latter being pure silica, that is, silicon (the base) united with oxygen in the proportion of one of silicon to three of oxygen. Silicic acid combines with the bases of metals and minerals forming silicates; almost all rocks and minerals consist of these silicates, more especially those of alumina, lime, magnesia, oxide of iron, potash and

Digitized by Google

soda, all of which, except those containing an excess of the stronger alkalies, are insoluble in water. The silica is rendered soluble by the action of potash and soda in the soil, so that it may be absorbed by the plant, as it is a necessary ingredient in forming the outer coat of the stalk of wheat and corn, by which these plants obtain their solidity and stiffness. Plants, whose length and thinness of stalks or stems are exposed to destructive influences require both solidity and stiffness to support them in an erect position, and this in all probability is the reason why the stems of the cereals rather than any other class of plants, contain so large a quantity of silica deposited in the stem and chaff, scarcely any in the grains. It always exists in a free state in plants, and does not participate to any important extent in the direct nutrition of vegetable life.

ALUMINA, or pure clay is every where found in great abundance. The sapphire and ruby are crystallized forms of alumina, and emery is a more massive as well as crystallizable form. Alumina forms the chief ingredient of all clays, and of most of the slaty rocks from which, through disintegration, the clays are chiefly derived. Pure alumina, however, is a fine white powder, quite unalterable in the fire. We frequently meet with it in chemical laboratories, precipitated from its solution in acids by alkalies; it forms in this condition a very bulky gelatinous hydrate, which when dried at a gentle temperature, is found to consist of aluminum 2 equivalents, oxygen 3, and water 6. When dry alumina is mixed with water, it forms a plastic mass which admits of being molded. This plasticity is imparted to the clay by the alumina, but were it absent, no potter could produce earthenware or porcelain.

Aside from imparting tenacity and firmness to the soil of which it constitutes a part, it absorbs moisture from the atmosphere, and with ammonia forms true salts. It also acts either as an acid or an alkali, because like an acid it unites with the alkaline bases of potassa, lime, and baryta; like an alkali by

Digitized by Google

forming *salts* with an acid. Our red and yellow clays are silicates of alumina and the peroxide of iron, united with lime, magnesia and sometimes with potash.

Potassium is a metal of a bluish white color, and has a metallic luster in a very high degree. If a portion of this metal is placed in a vessel and covered with naptha (a transparent mineral fluid, containing no oxygen whatever), and then a gentle heat applied, it will be found that it melts at a temperature considerably less than that of boiling water; and while in this state it much resembles quicksilver or mercury. It is lighter than water, and consequently floats on it. Potassium has so great an affinity for oxygen that unless kept in a vessel under naptha, it is in a short time converted into a white solid oxide, in which latter state we know it best. Every one is familiar with it under the name of Potash; combined with nitric acid, potash forms the saltpetre of commerce. In consequence of the strong affinity which Potassium has for oxygen, it readily decomposes the oxides or chlorides of aluminum, as well as silicic acid.

Oxide of Iron, or Iron Rust, is perhaps the most widely disseminated of all metals. There is scarcely a mineral, a soil, or a rock which does not contain, in a greater or less quantity, the oxide of iron. Chalybeate waters are so called because they contain in solution the carbonate of Iron. Iron has a strong affinity for oxygen.

Iron not only constitutes a portion of the food of plants, but acts as a concentrator or condensor of gases from the atmosphere which form a part of the food. Peroxide of Iron and alumina, says Liebig, are distinguished from all other metallic oxides, by their forming solid compounds with ammonia. The precipitates obtained by the addition of ammonia to salts of alumina or iron are true salts in which the ammonia is contained as a base. Minerals containing alumina or oxides of iron also possess in an eminent degree the remarkable property of attracting ammonia from the atmosphere and retaining it. Soils therefore containing the oxides of iron

Digitized by Google

and burned clay, must absorb ammonia, an action which is favored by their porous condition; they further prevent by their chemical properties the escape of the ammonia once absorbed. Such soils act indeed precisely as a mineral acid would do if extensively spread over their surface. The ammonia absorbed by the clay of ferruginous oxides is separated by every shower of rain and conveyed in solution to the roots of the plant.

MICA occurs confusedly crystallized as one of the constituents of granite, at other times it is found in large hexagonal or six-sided plates in porphyry and primitive limestone. It is commonly called Isinglass, from its remarkable transparency. The analysis by Klaproth gives—

Alumina	20.00
Silica	47.00
Oxide of Iron	15.50
Oxide of Manganese	1.75
Potassa	14.50

All these ingredients have just been described with the exception of the manganese, which is not always found in soils and yet more rarely found in plants, so rarely as not to be indispensably necessary to the growth or luxuriance of the plant. It is always found in some compound form, never as a pure metal. When artificially produced the metal is hard, brittle, of a grayish white color; as a metal it is not applied to any useful purpose; but the various oxides are extensively used in chemical manufactures—one preparation of manganese, the sulphate, is extensively used in calico printing.

The remaining undescribed ingredient of the granite rock is hornblende—this occurs crystallized with the feldspar and quartz. The crystals are confused and aggregated; sometimes however, they are long flat and hexagonal and prismatic—exhibiting fibers which are tough and rather difficult to break. According to Klaproth it contains—

Digitized by Google

Silica	42.00
Alumina	12.00
Lime	11.00
Magnesia	2.25
Oxide of Iron	80.00
Ferruginous Manganese	.25

In the hornblende we find two substances, Lime and Magnesia, which have not yet been noticed.

The metal mentioned by metallurgists and chemists as calcium or lime, is very little known, but is described as being a metal of a dark gray color. The metal rapidly oxidizes in the atmosphere; in this state it is known to all as quick-lime. Lime in the form of a carbonate is very abundant, and in this form we recognize it as marble, common limestone, chalk, oyster and muscle shells. Sulphate of lime is gypsum or plaster of Paris, so also is alabaster—this latter is much finer however than the gypsum. Common limestone or marble, when burned, becomes quick-lime. The phenomenon of slacking quick-lime is familiar to all—in this process every ton of limestone absorbs one fourth of a ton of water, which becomes a part of the stone itself. The action of lime in the soil is not yet thoroughly understood; but some writers assume that it promotes the decay of organic matters contained in the soil, hastening their conversion into carbonic acid and ammonia, from which they assert that plants derive their food. Lime is generally present in larger quantities in the ashes of plants than magnesia. The cereals contain, perhaps, the smallest quantities of lime; in the ashes of the grain, about 3 per cent. is found; in the straw of winter wheat and rye about 5 per cent., while that of the summer cereals contains from 7 to 9 per cent. The probability is that the carbonate of lime is requisite to form a portion of the product itself, and that it assists in decomposing minerals containing potassa, and converting it into a soluble form for the nourishment of the plant. The ashes of potatoes contains 2 per cent. only of lime, while the tops contain from 30 to 60 per cent. The

Digitized by Google

turnips contain from 6 to 12 per cent., while the tops contain 15 per cent. When lime contains a certain proportion of clay it becomes a cement. Limestones containing 8 to 12 per cent. of clay, furnish a hydraulic lime, which hardens under water in 15 to 20 days; when 18 per cent. of clay, it hardens in 8 days; if 25 per cent. it will harden in 3 or 4 days; Roman cement contains 35 to 40 per cent. of clay, and hardens in an hour.

Sulphite of Lime is a compound containing one equivalent of sulphuric acid less, and two equivalents of water more than gypsum, and has recently been very successfully employed in the extraction of sugar from beet root; this substance prevents the pulp from changing color by exposure to the air and the loss of sugar by fermentation.

Sulphate of Lime, or gypsum, if allowed to remain when in solution in a state of contact with organic matters is reduced to sulphide of lime, which, under the influence of water and carbonic acid, is converted into carbonate of lime. Nearly all the plant-ashes contain this substance, it is therefore of great importance to the plant.

Phosphate of Lime, an ingredient so essential to the cereal plants as well as to the animal frame, is found in the mineral kingdom.

Traces of phosphoric acid are found in a great number of rocks and stones in the soil, in almost all plants and in animal matters. It never occurs free, or uncombined, but always in combination with a base—most generally with lime. Phosphate of lime is always found in wheat, and all the vegetable substances which constitute part of the food of man and animals; and we find it in a very considerable quantity associated with carbonate of lime in coprolites (or fossil manure of extinct animals), and other forms of fossil manures, which of late have been much talked of, but is by no means abundant in the latter. When bones are burnt, there remains, after the combustion of all the organic matter which they contain, about three-fourths of their weight of earthy substances; this is

Digitized by Google

phosphate of lime, together with a small portion of carbonate of lime; bones consist of phosphate and carbonate of lime, cemented together as it were with gelatine and a little albumen—they also contain a small quantity of oil. Phosphate of lime is insoluble in water, but readily dissolves in solutions containing a little free acid.

Magnesium is a silver white metal, but as a metal is rare and is not employed in any useful purpose. Like most of minerals and metals, it readily unites with oxygen, forming oxide of magnesia or common magnesia. In the drug shops it is sold as a white powder. When united with sulphuric acid it forms the ordinary epsom salts of commerce. Magnesia is found in the ashes of many plants, but what action it has upon other ingredients of the soil is not understood sufficiently to warrant an expression.

These ingredients, being the chief ones of the soil, are all derived from granite through disintegration by the incessant action of the elements, of rain, dew and frost during the lapse of untold ages. These have served to comminute and separate the original ingredients from each other, and to recombine them so as to form new compounds. Granite undoubtedly is the primary rock in the geological series, that is to say, it is the base from which all other rocks are derived. The first *stratified* rock is *gneiss*, which is nothing more than granite, which always occurs in shapeless masses, decomposed under great pressure, perhaps under some vast ocean—the gneiss strata became upheaved, the bed of the ocean changed, and the gneiss, now in its turn is decomposed, and the particles separated—the feldspathic portion forming the various slates, the lime being held in solution, is deposited in separate strata, the mica forming the mica schists, and in combination with the feldspar, forming the mica slates. These secondary or derivative rocks in turn undergoing decomposition, forming new combinations more recent rocks and strata, until at length the feldspar has been resolved into clay, the quartz into sand rock, the lime universally diffused, and in places deposited in

Digitized by Google

ledges of rocks, often measuring thousands of feet in thickness, and many miles in extent. The action of the rains, frosts, etc., acting on granite and other rocks, and disintegrating them, is called mechanical disintegration; but nature has adopted and employed yet another means of reducing rocks, which is recognized as chemical disintegration or decomposition. Those minerals which contain metallic sulphurets, become, by the gradual absorption of oxygen converted into sulphates, which are not only soluble in water, but absorb moisture from the air, and thus crumble down. In the disintegration of silicious minerals the process is equally simple. Silica is insoluble in both hot and cold water; it unites with alkalies and forms the saline compounds known as silicates which have been previously mentioned; the silicates of potash, soda and lime, are neutral compounds, and as this property of neutralising metallic oxides and alkalies belongs to acids, only silica has received the name of silicic acid; this acid is, however, very feeble, for all the soluble silicates can be decomposed by carbonic acid. The action of water containing carbonic acid becomes very manifest on quartz. Liebig mentions an experiment in which some white sand was thoroughly cleansed by boiling in nitro-muriatic acid, and after completely removing the acid by washing the sand with water, the sand thus purified was exposed to the action of water saturated with carbonic acid. After a lapse of thirty days this water was analyzed, and found to contain in solution, silica, carbonate of potash, lime and magnesia; thus proving that the silicates contained in the sand were unable to withstand the continued action of water containing carbonic acid, although the same silicates had resisted the short action of the nitro-muriatic acid.

So also in nature, feldspar, as well as the minerals and rocks containing silicates of alkaline bases, can not resist the continued solvent action of carbonic acid dissolved in water; and in this way, either in the form of soluble silicates or a hydrate of silica, this important ingredient, in some plants, is taken

Digitized by Google

up by the roots. It may perhaps be objected by some that feldspar could not furnish the amount of potash necessary for the growth of dense forests as well as the cereal and other cultivated crops. Liebig, who is perhaps the best authority on all subjects connected with physiological chemistry, says that a cubic foot of feldspar will furnish the necessary amount of potash to supply an oak copse covering a surface of nearly one acre, for five years. About ten per cent. of the heart wood, and 13 1-2 per cent. of the sap wood of oak is potash.

In addition to the mineral earths and metals already mentioned, there are other ingredients formed in soils; among these are:

Sodium is a silver white metal, having a very high luster, and is perhaps more abundant than any other, for it constitutes two-fifths of all the sea salt existing in sea water, in the water of springs, rivers and lakes, in almost all soils, and in the form of rock salt. Sea salt is a compound of sodium with chlorine—sodium also occurs as oxide of sodium or soda in a good many minerals, and more especially in the forms of carbonate, nitrate and borate of soda; these forms of this metal are undoubtedly to be attributed to the process of chemical disintegration of primitive rocks.

Soda or sodium is a necessary constituent of the soil, in which it performs a part not much unlike potash, for which it may be substituted to a great extent.

Phosphoric acid is of equal if not more importance than silicic acid, is found in all rocks of primitive origin. In the animal kingdom it is found as phosphate of lime, magnesia and ammonia; the fact that it is found in the ashes of all the cultivated plants, is sufficiently indicative of the part it performs in the vegetable economy—it contributes about ten per cent. of the ashes of the roots of the red beet; about forty per cent. of the ashes of the grain of Indian corn; about fifty per cent. of the ashes of buckwheat grains.

Notwithstanding, a soil may produce a large and rank growth of straw, unless phosphoric acid is present in sufficient

Digitized by Google

quantity, and in a proper form for the plant to assimilate it, there will not be a corresponding yield of grain. Hence in soils in which this condition of things is manifest, the agriculturist may increase the quantity of grain by the application of manures containing this ingredient.

Sulphuric acid, or oil of vitriol, occurs in large quantities in the mineral kingdom, in combination with various bases, such as the alkalies and alkaline earths. In New Granada, in South America, this acid has been discovered in the uncombined state in a thermal spring. In the soil sulphuric acid acts rather as a solvent of other ingredients than as a food for plants, although it is found in various combinations in the ashes of plants. It exists most abundantly in the tops of turnips, potatoes, and plants of this class, amounting to five to ten per cent. of their ashes. There is more of it contained in the straw than in the grain of the cereals; it is most abundant, however, in the ashes of oil-producing seeds.

The foregoing constitute the tangible *ponderable* bodies (that is, the bodies that are considerably heavier than common air) which are contained in the soil, and that are absorbed and assimilated by the plant. The soil not unfrequently contains other substances from which the plant can derive no nourishment, and which proves an injury rather than otherwise, to the plant; such are, for example, oxide of lead, copper, etc. There are four gases, however, whose presence is as absolutely necessary to the successful growth of plants as that of any of the ingredients of the soil, these four gases are named carbon, hydrogen, oxygen and nitrogen. All that portion of the plant not derived from the ponderable bodies of the soil, as well as the whole atmosphere of the globe, all the water, and a very considerable portion of the solid rocks which compose this earth consist of one, two, three, or all of these gases combined in different proportions. Carbon is generally found as a solid, but the remaining three occur as pure gases in nature.

Digitized by Google

Carbon.

In its pure and crystalized state, carbon is the most highly valued of all precious gems—the diamond. Incredible as it may appear, common charcoal and the diamond are composed of precisely the same elements. All the mineral or fossil bituminous coal, cannel coal, anthracite coal, are chiefly carbon; it occurs in many minerals in combination with oxygen, and in this form is known as carbonic acid. As it forms nearly fifty per cent., or one-half of all vegetables, it follows that it is one of the most important ingredients in vegetable economy. It possesses the peculiar property of absorbing several of the other gases; hence its great utility in preparing or solving other ingredients for the benefit of the plant. It has a great affinity for oxygen, and combines with it in the proportion of one equivalent of carbon with two of oxygen; in this combined state it is known as carbonic acid, and is readily absorbed by water, imparts to it a lively, sparkling appearance, and a slightly sour taste. In the decomposition of animal and vegetable matter, it is evolved or taken out, and as it is heavier than the atmosphere, it not unfrequently collects in low places, and is known as *choke damp*, in wells, which so often proves fatal to those who incautiously venture into such places.

When carbonic acid gas is combined with hydrogen, it forms the gas which is used in cities and towns for illuminating purposes. This combination is found in nature, and is the product of the decomposition of vegetable matter under water; hence it is almost always present in the vicinity of stagnant pools of water, and is known as "*marsh gas.*" In coal mines it frequently accumulates in large quantities, and is known by the miners as "*fire-damp*," and when approached with an unprotected lighted candle or lamp, not unfrequently explodes, causing serious consequences.

Oxygen.

Oxygen is a gas which is colorless, tasteless and inodorous, and is the most extensively diffused element in nature. It

Digitized by Google

constitutes about one-fifth of the entire atmosphere, the remaining four-fifths being nitrogen. It forms about eight-ninths of all the water on the globe; it enters as a constituent into nearly all the earths and rocks, and with few exceptions combines with all the metals. Oxygen is the acid or sour principle in nature; hence the German chemists have termed it "*sour stuff*." It was called "oxygen" (meaning the sour principle) by Lavoisier (although it was discovered almost simultaneously in 1774 by several others), because all known acids at that time were supposed to contain this element. At the present time chemists enumerate quite a number of acids which are destitute of oxygen, and many circumstances tend to favor the view that hydrogen is the real acidifying principle. Oxygen is a restless, unconquerable element, and among the whole catalogue of simple bodies or elementary substances, there are none that seize, attack, change and destroy so much as it does. It unites with almost all other bodies with which it comes in contact, and changes or destroys them; and as it forms a portion of the air, and most of the water, what can escape its presence? When it combines with any body, the combination is called oxidation or rusting; when it combines with iron, as is the case when iron is wet or damp, or heated to a white heat, we say the iron is rusted—the chemist says it *oxidizes*. But notwithstanding the eagerness of oxygen to seize upon and destroy every thing, there is an agent whose services are indispensable, and without whose aid oxygen entirely fails to accomplish any thing. This agent is warmth. If we desire to secure any object against the destructiveness of oxygen, all that is necessary to be done is to deprive that object of all warmth, and the object is accomplished; it is somewhat upon this principle that fruits put up in cans retain their freshness for a great length of time. The fruits so put up must be deprived of all contact with oxygen, sealed so tight as not to permit the admission of the least particle of air; then placed where the temperature is near 32° Fahr., and the fruit is safe. In proof of the necessity of the absence

Digitized by Google

of warmth to secure against the attack of oxygen, one circumstance may be deemed sufficiently conclusive. There are portions, and in some cases entire bodies of elephants imbedded in the ice in the northern portion of Siberia, and have been thus imbedded for thousands of years. Several years since a scientific corps from France visited the mouth of the river Lena, where the imbedded elephants are, and removed several entire carcasses. They found the flesh in an excellent state of preservation, retaining even its color in a remarkable degree; and as soon as it became sufficiently thawed, the dogs that accompanied the corps ate it with great avidity. So long, then, as oxygen was kept at or below the freezing point, it could not with any success whatever attack the flesh, but as soon as warmth was added, all its energies were called into activity.

Napoleon III. conceived the idea that flour could be compressed into a smaller space than it generally is by millers. A series of experiments were instituted to determine whether any economic advantages could be gained. The result was a complete confirmation of the principles taught by chemistry, namely, the flour which underwent the greatest compression contained the least atmosphere, and would consequently be in a better state of preservation for a greater length of time—other things being equal—than that put up in the ordinary manner. The pain from a fresh wound is chiefly to be attributed to the fact that oxygen insinuates itself into every part of the wounded surface. If, when a wound is first received, it is immediately covered with a piece of court plaster, it will heal without either pain or suppuration. The plaster does not heal the wound, but it keeps the wounded parts in juxtaposition, and at the same time excludes the oxygen, and prevents it from irritating the affected surfaces, thus affording nature, or the vital force of the system, an opportunity of uniting the severed portions, or supplying that which was torn away; hence the superiority of one salve, ointment or plaster over another is its better adaptation to exclude oxygen only.

Digitized by Google

When oxygen combines with iron, the result is a harmless combination—one which may be handled with the nude fingers with impunity; but when oxygen combines with sulphur, the resultant combination is not quite so harmless, but is known as sulphuric acid, or oil of vitriol, which "*eats*" iron, copper, wood, and clothing of all descriptions.

When oxygen combines with metallic bases, the resultant compounds are called oxides, and are recognized by chemists as *alkaline* bases. But when oxygen combines with non-metallic bases, then the result is an acid; thus, when oxygen combines with sulphur, the product is sulphuric acid; with silicon, silicic acid; with carbon, carbonic acid, etc. When an oxide combines with an acid, the resultant compound is a salt, as, for example, when oxide of iron combines with sulphuric acid, the result is a green salt, known as green vitriol, or copperas; when oxide of copper combines with sulphuric acid, the result is sulphate of copper, or blue vitriol. Saltpeter is a combination of oxide of potassium and nitric acid; the elements of the same acid combined in a different proportion constitute our atmosphere. Acids are excellent agents to clean oxydized or "*rusted*" metallic surfaces, because the acid combines with the oxide and forms a salt which is readily removed.

Oxygen will combine with other bodies, as before stated, by the agency of heat only; but during the combination heat is evolved, which is a preparatory step toward forming a new combination. No oxygenized substance contains as much heat as the non-oxygenized. In every oxydation heat is evolved, and the greater the heat, the larger the amount of matter that combines with oxygen. Oxygen is a gas, and if the combining body is gaseous also, then the combination may take place instantly, and heat to such a degree be evolved as to emit light; this preparatory combustion is called *burning*, and the light of the heat is called *fire;* hence it is evident that the combination of any body with oxygen is a combus-

Digitized by Google

tion. because the combining body becomes changed and heat has been evolved, not at all times, and in some instances at no time to such a degree as to be lighted or ignited; but the process is nevertheless a *slow* burning. Oxydized iron is according to this view nothing more than iron slowly burned; decayed wood is wood slowly burned; and decomposing flesh is nothing more than flesh being slowly burned. Oxygen is the factor which returns all substances to the earth whence they were taken, and the process by which materials are returned or converted into their original elements is combustion.

Oxygen is indispensably necessary for supporting respiration, animal heat and life being dependent upon a gradual combustion in the system.

Nitrogen.

Nitrogen is a transparent gas, without color, odor or taste. It is distinguished for its negative properties, that is, it will neither support life nor combustion, but appears to act simply as a diluent to the oxygen of the atmosphere, of which latter it appears to constitute about four-fifths. It is not inflammable, but on the reverse, if a lighted taper be plunged into it, the taper will immediately be extinguished. It is a little lighter than atmospheric air. It will not support vegetation alone, and animals soon die when placed in it. It is, however, an essential ingredient of all animal tissues, and of all such vegetable products as can be converted into blood in the animal body; also of the vegetable bases and other vegetable compounds, such as indigo, etc. It can not be made to unite directly with any element, and only forms combinations when one or both elements are in the nascent state. It is, therefore, unlike the other metalloids, in a high degree chemically indifferent or neutral. But under favorable circumstances, it does combine with most of the metalloids and with several metals. However, its most important compounds are those with oxygen, and with hydrogen. Among the latter, the

Digitized by Google

most prominent is ammonia, a substance with which all are familiar, by smell at least, who have had occasion to go to stables or places where animals, more especially horses, are kept and littered at night. The smell arising from the urine of animals is peculiar, affecting the nostrils not only in a pungent, but in a pricking manner. Others are familiar with it under the name of spirits of hartshorn, or volatile alkali, which is ammonia combined with water. It possesses strongly alkaline or basic properties, and neutralizes the strongest acids; hence it is of great importance to the agriculturist.

Hydrogen.

Hydrogen is a gas, colorless, tasteless, and when quite pure, devoid of smell, but as it does not exist uncombined in a state of nature, it must be prepared from substances which contain it in considerable quantities. It forms eleven per cent. of water by weight, and is found in many minerals, all animals, and all vegetables. It is eminently combustible, but will not support either combustion or animal life. Hydrogen gas is not absorbed by water, neither does it combine so readily with other bodies as oxygen does. It may be made, however, to combine with most of the metalloids, and with a few of the metals.

Chlorine.

This element was discovered in 1774 by Scheele. It is never found free, but in combination with some other element only; it is a very poisonous, corrosive, yellow-colored gas, causing very great irritation when breathed, even when largely diluted with common atmosphere. It is now extensively used in bleaching establishments, but as it is a very powerful agent, if not carefully used, the texture of the goods will be destroyed, and become quite rotten. From this cause common writing paper is often found to be quite useless, the rags from which it was made having been too strongly saturated with chlorine while in the bleaching process. Chlorine readily combines with the metals, and most of the other elements to

Digitized by Google

form a series of compounds, called chlorides. When combined with hydrogen, it loses all these peculiar powers, and forms a strong acid—the muriatic—which, by combining with bases, forms a series of salts called muriates.

Chlorine is especially found in the straw or leaves of our cultivated plants. Its quantity is also considerable in the stalks, leaves and roots of the bulb-producing plants. In the ashes of the grains or seeds of our cultivated plants, it seldom exceeds one per cent. WAY, however, found six to eight per cent. in the ashes of the barley straw.

AMMONIA.

Ammonia is the next important substance essential to the growth and development of the plant. Ammonia is a combination of hydrogen and nitrogen, and occurs in the atmosphere as carbonate of ammonia, in mineral waters as chloride of ammonia—it also occurs in brook, spring and rain-water; the common yellow clay will yield ammonia when heated after having been exposed to the action of the atmosphere. Ammonia is found in animal secretions and excrements; in fact, carbonate of ammonia was at first very extensively manufactured in Egypt from Camel's dung.*

Competent chemists state that there is a sufficient amount of ammonia contained in rain-water to supply the growing crops; but should the supply fail from drought, then the supply is undoubtedly obtained from the soil, either from the barn-yard manure, the clay or the lime; for there is scarcely a limestone in existence which will not, under certain chemical processes, yield ammonia. Decaying animal bodies emit

* Ammoniacal liquor or gas liquor is extensively obtained in the condensing vessels of coal-gas works. Some agriculturists who were aware of the importance of ammonia in the growth of vegetables, have been impressed with an idea that the application of gas liquor to growing crops would have a favorable effect. I know of no instance in which the hopes of the experimenter were realized. Gas liquor contains carbonate, hydrocyanate, hydrosulphate and sulphate of ammonia.

Digitized by Google

ammonia, that is, whenever the decomposition of animal substances is effected with the assistance of water, their nitrogen is invariably liberated in the form of ammonia. Liebig says this is a fixed rule without any exceptions, whatever may be the causes which produce the decompositions. All organic compounds evolve the whole of their nitrogen in the form of ammonia when acted on by alkalies. It is well known that all "wheat" and "potato" soils contain alkalies; hence, whenever nitrogenous manures are introduced, there is speedily as much ammoniacal salts produced as the growing vegetation may require. In 1846, Dr. Krocker, of Germany, examined a number of soils to determine the amount of ammonia which they contained. Annexed are the results of his investigations in tabular form:

TABLE OF THE AMMONIA CONTAINED IN THE SOIL.

BY DR. KROCKER.

Soils Examined.	Ammonia in 100 parts of Earth dried in the Air.	Specific Gravity.	Ammonia in a stratum of solid Matter 0.25 meter thick, on 1 hectare, in pounds.
Clay soil, before manuring	0.170	2.39	20314
Clay soil	0.163	2.42	19723
Surface soil, at Hohenheim	0.156	2.40	18730
Subsoil of the same field	0.104	2.41	12532
Clay soil, before manuring	0.149	2.41	17953
Clay soil, before manuring	0.147	2.41	17713
Clay ready to be sowed with barley	0.143	2.44	17446
Clay soil, before manuring	0.139	2.41	16749
Loamy soil, before manuring	0.135	2.45	16537
Loamy soil, before manuring	0.133	2.45	16292
Earth from America, never manured	0.116	2.18	12644
Sandy soil, never cultivated	0.096	2.50	12000
Loamy earth, dug out	0.088	2.50	11000
Sandy soil, never cultivated	0.056	2.51	7028
Nearly pure sand	0.031	2.61	4045
Marl	0.0988	2.42	11952
	0.0955		11552
	0.0768		9288
	0.0736		8904
	0.0579		7004
	0.0077		931
	0.0047		568

Digitized by Google

Porous substances have the power, as a general thing, of condensing ammonia; hence soils condense and retain it till called into action by water or carbonic acid to be assimilated, and form a portion of the growing plant. It is capable of undergoing quite a number of transformations when in contact with other bodies. When pure it is extremely soluble in water; it forms soluble compounds with all the acids, when in contact with certain other substances it is capable of assuming the most various and opposite forms, in which one would not suspect so caustic an alkali was participating. Chemistry teaches that formate of ammonia, under the influence of a high temperature, changes into hydrocyanic acid and water, without the separation of any of its elements. Ammonia forms urea, with cyanic acid, and a series of crystalline compounds with the volatile oils of mustard and bitter almonds.

Humus.

Much has been written upon the influence of humus upon the growth of plants, and it is highly probable that very little is absolutely known of its importance, or manner of action. Humus has been defined by chemists to be vegetable substances in a state of decay, as roots of crops. dead leaves, etc. Those who have paid especial attention to its action, and have conducted experiments with no other object in view than to ascertain the part it plays, have reluctantly concluded that, in the form in which it exists in the soil, it does not yield the least particle of nourishment to the plant. It is well known that vegetable mold forms a rich soil, and that plants grow rapidly and attain a much greater size in spots where much vegetable matter has decayed, or is in an advanced state of decay; investigators, therefore, were much disappointed when they found that humus yielded no nutriment directly to the plant. But it is of the utmost importance as a constant source of carbonic acid. Woody fiber, chips, roots of crops or decaying leaves, when moist, convert the oxygen gas with which they come in contact into an equal volume of carbonic

Digitized by Google

acid. Very few soils which contain vegetable matter, are so compact as to exclude the atmosphere; there is thus a constant conversion of oxygen into carbonic acid, and it is not improbable that in compact soils the plant itself absorbs oxygen from the atmosphere, for the purpose of having it converted into carbonic acid, by bringing it into contact with the vegetable matter. When we loosen the soil which surrounds the young plants, we favor the access of air, and as a matter of course we accelerate the formation of carbonic acid; in this consists the great benefit of "hoeing" or "cultivating" plants.

Humic substances all contain, naturally, water and ammonia in various proportions, and occur in black turfs, soil and root. From humus is obtained an acid called humic acid, which has a great tendency to absorb ammonia, and holds it so firmly that even by boiling with carbonate of soda it does not escape. The best agricultural chemists are, however, of opinion that no humic acid is found in the soils. The action of humus then is merely to furnish a supply of carbonic acid, and hasten the development of the plant; as it is a law in vegetable physiology, that when the food of a plant is in greater quantity than its organs require for their own perfect development the superfluous nutriment is employed in the formation of new organs, that is, new roots and fibrils, new branches, leaves, etc. Hence wheat tillers or stools most when sŏwn in good soil, and protected by a good covering of snow.

The position that humus, as such, is of no importance whatever, or that very excellent crops can be grown *without* it, is strikingly illustrated by the fertile soil around Naples. Those who have traveled there state that the farms and villages are situated from eighteen to twenty-four miles from one another, there being no roads leading from the one to the other, consequently there has been no transportation of manure. The cereals have been cultivated there for many hundreds of years—perhaps thousands, without any restora-

Digitized by Google

tion being made to the soil of any part of that which has been removed from it. And yet these lands are famous for the abundant crops they bear, while there is no proof positive that any humus was ever contained in the soil. On the other hand, wheat does not thrive in many parts of Brazil, where the soils are particularly rich in this substance; or in our own climate where soils are formed of moldered wood, that its stalk under these circumstances attains no strength, and droops prematurely. It is well known that the strength of the stalk is due to silicate of potash, and that wheat, as well as all other cereals, require certain phosphates which are not found in a soil containing humus in a great proportion. Therefore, wheat grown in soils rich in humus have tender stalks, diminutive heads and no seeds.

Humus is said to be absolutely insoluble in pure cold water, but is soluble when combined with oxygen, and in that condition is taken up by water as carbonic acid.

Mulder includes among the substances which fix the ammonia in a rich soil, the five acids which he discovered in the humus, namely ulmic, humic, geic, crenic and apocrenic acids, The acids which are formed during the decay of animal as well as vegetable substances, decompose the carbonate of ammonia which is conveyed to the soil by rain, and having thus become soluble, are transferred, in the form of ammoniacal salts, to the roots of plants, where they are rapidly decomposed (even in the extreme end of the root fibrils) and are converted into other bodies.

When any of the above mentioned acids are found in the soil, they are generally united with bases, especially with ammonia. They should perhaps be regarded as the products of different stages of decay, because as the process of decay does not cease, organic constituents are subject to a constant change; thus by the oxidation of ulmic acid arises humic acid; from humic acid geic acid, and in like manner, by the oxidation of geic acid, crenic acid may be formed. The constitution of these matters is expressed by the following empirical formulæ:

Digitized by Google

Ulmin	C. 40	H. 16	O. 14
Ulmic acid	C. 40	H. 14	O. 12
Humin	C. 40	H. 15	O. 15
Humic acid	C. 40	H. 12	O. 12
Geic acid	C. 40	H. 12	O. 14
Crenic acid	C. 24	H. 15	O. 19
Apocrenic acid	C. 48	H. 22	O. 24

Of these substances crenic acid is soluble in water; apocrenic, ulmic, and humic acid dissolve in alkalies; ulmin and humin are insoluble in water and in alkalies; but to a certain extent they can be made soluble by being changed into ulmic and humic acids.

Digitized by Google

CHAPTER VIII.

NUTRITION OF THE WHEAT PLANT.

THIS brief description of inorganic substances, enumerated in the preceding chapter, most all of which are invariably found in the ashes of the wheat plant and its fruit, has been deemed necessary, from the fact that those most deeply interested in the culture of the wheat plant, have the least opportunity to become familiar with elements whose operations they witness daily, and whose individual functions can not be determined by simply plowing and seeding.

A description has now been given of the constituents of the wheat plant, as well as hydrogen, nitrogen, and oxygen as organic elements, and silica, alumina, potash, soda, lime, magnesia, sulphuric acid, phosphoric acid and chlorine as inorganic elements. By what process has the plant extracted these different elements from the soil? By what intelligence or instinct is it guided in selecting the proper and rejecting the improper elements? These and similar questions are ever demanding our attention, but physiological chemistry is not sufficiently matured to furnish positive intelligence upon the points necessarily involved, notwithstanding great, nay, really giant strides have been made in this direction by Liebig and his co-laborers, yet in many cases conjecture is obliged to supply the place which should be occupied by certainty.

These conjectures may prove of great service to the agriculturist if he will accept them as conjectures only, and not regard them as ascertained facts, upon which he may rely with certainty, in his practical operations. It may not be inappropriate to state what is known with certainty, and what methods have been adopted to ascertain not only the functions performed by the different portions of the plant, but the processes

Digitized by Google

of growth and assimilation of the earthy, mineral, and other substances which constitute a part of the plant.

In Chapter VII. I have endeavored to state clearly and fully the entire process of germination, chemical and physical, together with functions performed by the roots and other parts of the plants, until it arrived at that stage when the parent store of food was exhausted, and it was obliged to seek the nourishment, for its future growth and existence, from the surrounding inorganic substances. The present, and two succeeding chapters, will be devoted to some of the phenomena of the growth of plants, and experiments of growing plants in artificial or entirely inorganic soils.

Every day observation teaches, and experience confirms, that in order to live and grow, plants must obtain nourishment. An opinion was long prevalent that plants existed and assimilated nutriment from the atmosphere, and that the inorganic elements found in the ashes of plants were purely "*accidental.*"

"Plants," says Berzelius (Handbuch, 1839, p. 77), "obtain the material for their growth from the earth and the air, which are both alike indispensable to them. The earthy part appears to exert on plants no other influence except only a mechanical one."

"According to the doctrines advocated by De Saussure and Sprengle, which were prevalent up to 1840, vegetable and animal life depended on the circulation of organic matter, formerly endowed with vitality. When all the remains of dead plants and animals in cultivated land had been set in motion, brought into the circulation, and in this way rendered available, an increase of produce by cultivation, beyond this limit, was no longer possible, nor an increase of the population conceivable."—*Journal of the Royal Agricultural Society.*

But these "accidental" occurrences, like Hamlet's madness, seemed to have a *method* or uniformity about them which led to the promulgation and adoption of the theory that plants possessed the power of changing, or converting one substance into another, for example, that they could extract silica, and

Digitized by Google

convert it into potash, where silica abounded in the soil and potash was deficient, and that on the contrary they could convert potash into silica, when silica was deficient. This theory was found untenable when it was discovered that the most abundant crops could not be grown on all descriptions of soil. Were the powers of the plant such as this theory supposes, then a soil composed of pure clay, or of pure sand, must be equally as fertile as a soil containing all the inorganic elements found in the wheat plant. But experience proves that every inorganic element found in the ashes of the wheat plant is essentially necessary to the proper growth and full development of the plant. Although lime forms less than one pound of the ashes of one thousand pounds of the wheat grain, yet this almost infinitesimal amount is just as essential, and of as much absolute importance to the health, growth and maturity of the plant as is the silica which is found to be almost five times the amount of the lime. As already stated, the plant has not the power of supplying deficiencies of the soil; and to this one fact may in a great degree be attributed the necessity for the various species, genera, order and families of plants. When the soil does not contain the necessary and appropriate elements for a certain plant, it fails to grow; but some other plant, to whose growth and development the wanting element is of no importance, will flourish on that spot. The reason why pitch pine and the sugar maple do not flourish on the same soil, is very obvious from an examination of the inorganic constituents of their respective ashes:

MAPLE.		PITCH PINE.	
Silica	0.40	Silica	7.50
Potash	4.62	Potash	14.10
Soda	2.90	Soda	20.75
Lime	41.33	Lime	13.60
Magnesia	6.42	Magnesia	4.85
Phosphate of Iron	.78	Phosphate of Iron	11.10
Phosphate of Lime	4.64	Phosphate of Lime	2.75
Phosphate of Magnesia	0.74	Phosphate of Magnesia	.90
Sulphuric acid	1.22	Sulphuric acid	8.45
Carbonic acid	35.90	Carbonic acid	17.50

Digitized by Google

While the maple requires less than one-half of one per cent. of the amount of its ashes of silica, the pine requires seven and a half per cent.; nearly half of the ashes of the maple consist of lime, while little more than one-eighth of the pine ashes are of the same element. But the pine assimilates fourteen times as much phosphate of iron as does the maple.

The vine will not flourish where there is no lime in the soil, while wheat requires a soil rich in phosphates. Tobacco, the walnut tree and celery leaves, contain saltpetre. Shœph obtained four grammes of crystalized saltpetre, from one hundred grammes of coarse stems of the tobacco plant. There are many facts which might with propriety be introduced to prove the absolute necessity for inorganic elements; as well as the peculiar influences which some inorganic elements exercise over some of the plants grown upon soils containing them. Carbonate of lime is found to exist in the superficial cells of some varieties of chara.* On the Galmei Hills, near Aix la Chapelle, is found the *Viola lutea caliminaria*, which owes the peculiar color of its flowers to the presence of zinc.† The reason why the tea grown upon the island of Java is not pleasant nor of so good a quality is because of the excessive amount of salts of iron in the soil. Several attempts have been made to grow the tea plant in the southern portions of the United States, but the failure to produce as good an article as that from China must be attributed to the soil.‡ It is a well known fact that in China the cotton is naturally of the color known as "*nankin*"—a light orange, caused by the salts of iron in the soil; seeds from the Chinese cotton plant have been planted and grown in the United States, but the cotton

* Ballingrodt. † Payen.

‡ This is undoubted true so far as *quality* is concerned, but tea culture can not be made profitable in the United States, for the reason that labor is too expensive. In China a tea gardener receives wages at the rate of about one dollar per month, and "boards himself." Any person, whether male or female, free or slave, competent to be a tea gardener can obtain a better remuneration for services than obtains in China.

Digitized by Google

had exchanged its "nankin" color for that of the cultivated Carolina cotton. In experiments conducted by Mr. Daubeny, he states that he found barley would assimilate three times as much potash as it would soda, notwithstanding many compounds containing soda in excess were added to the soil. A heath plant (*Erica carnea*), growing abundantly in the plains in the valley of the Lech river, is remarkable for the great proportion of lime which it assimilates, while another heath plant (*calluna vulgaris*), closely related, but of a different species from the former, growing on the hill-sides of the Lech is equally remarkable for the amount of silica which it contains.* Struve found 100 parts of the ashes of equisetum hyemale to consist of 97 parts of silicic acid. If further proof were needed that plants require inorganic substances as their chief source of nutrition, a reference to the example of the lichen, or moss growing on the bare rock, may with propriety be made. The moss obtains its nutriment entirely from the rock which it decomposes, except it shall be demonstrated that plants receive nutritive substances or elements from the atmosphere. Saussure and others have proved that the seeds of beans, *Phaseolus vulgaris*, of peas, and of garden cresses, germinate and even grow to a certain extent in moist sand or moistened horse hair; but the plants began to droop as soon as the mineral substances contained in the seeds were exhausted; and notwithstanding some of them even bloomed, they could not possibly produce seeds, for the reason that the constituents essential for the formation of seeds were entirely absent.

"When we reflect that no plant can exist independently of certain *mineral* constituents, and that these occur only in certain definite quantities, and that some bases only, such as soda or potash, lime or magnesia occur in plants—and when finally we observe that these mineral substances are accumulated in very different proportions in the various organs of plants, and in accordance with the different periods of their development,

* Roethe.

Digitized by Google

although they present tolerably uniform relations under similar conditions and in identical organs—we are necessarily led to the idea that these substances exert a definite influence upon the life of the whole plant, and upon the origin of its organic constituents from carbonic acid, water and ammonia." —*Lehman.*

Plants undoubtedly have the inherent or vital power to imbibe and exhale the atmosphere, or in other words plants breathe; but this breathing process is by no means a nutritive one to either plants or animals; yet it is essentially necessary to both to enable them to assimilate substances for nutritive purposes which have been received within their respective organizations.

How does the plant obtain its nutriment from the soil; and if it is nourished by inorganic or mineral substances only, how or by what process are these rocky and earthy substances dissolved and liquefied so that they may be absorbed by the plant?

A summary abstract has already been given of Mr. Osborne's observations and experiments; but it must be borne in mind that his experiments extended no further than the growth of the plant, until the period of the exhaustion of the albuminous body, or the amount of nutriment prepared by the parent plant for the existence and development of the embryo, until it had attained sufficient growth to elaborate nutriment from the soil. His observations and experiments extend no further then than the period during which the embryo or fœtus receives its nourishment from the parent through the umbilical cord. The plant must now be considered as having the umbilicus severed, and commencing life on its own account—dependent for its nourishment—its daily bread—on its own industry.

By what process do the roots absorb moisture or liquids from the soil? Physiological botanists are divided in opinion upon this question. While the one party affirms that the plant is endowed with vitality, and that this vitality is sufficiently powerful and manifest to absorb by inspiration (mean-

Digitized by Google

ing a vitalized capillary attraction), another party as confidently asserts that the plant receives its nutriment from the soil by *endosmosis* (inside impulsion), thus practically denying to the plant all vitality, because the process of the endosmosis and exosmosis is a purely mechanical one. It may not be inappropriate in this connection to detail the process and experiment of endosmosis and exosmosis. Take a glass tube of any convenient length, and firmly tie a piece of bladder over one end of the tube; if the tube be now partially filled with a strong solution of common table salt, it will be found that the solution will not penetrate through the epidermis, in case the tube is suspended in the air. But if the tube be inserted into a vessel containing pure water, the solution of the salt will be found to have permeated the bladder and impregnated the pure water with a saline taste; at the same time the volume of the solution in the tube will have been augmented by the pure water penetrating the bladder and commingling with the saline solution. The act of the pure water, or *outside* element finding its way through a membrane or integument so as to commingle or be assimilated with the inside element is termed *endosmosis;* while the reverse act (although simultaneous) is termed the *exosmosis;* but both these actions are purely mechanical, because they may be successfully performed by substances entirely devoid of any vitality.

The doctrine of endosmose has undoubtedly obtained considerable support from the well known fact, that plants absorb indiscriminately all substances held in solution in water; but then they give off through their roots (*Liebig*, *Mulder*, *Lehman*), or through other parts, all matters which may injure their vital activity. If plants possessed the power of selecting or absorbing such substances only as were essential to their growth and development, the problem of nutrition would be one of comparatively easy solution; but as they do not possess this power the problem is exceeding complex, and with the most diligent research, assiduous investigation and observation our knowledge of the relations existing in the nutritive

Digitized by Google

process of vegetable organisms is so very circumscribed and imperfect "that it is much less easy to establish a convincing refutation than to adduce a strict proof."

It is, however, a fact established beyond successful contradiction that the roots of plants absorb moisture and liquids from the soil, and that the functions of the roots are other than a mere support to retain the plant immovably, and in an upright position. The fluids are unquestionably drawn from the soil by the roots under the influence of a *vital* force or power, and not a mechanical one, for were the doctrine of endosmosis correct, it is not very obvious that there could be any annual plants, or that roots would decay, without being removed from the place where they grew.

Isert, a Danish physician, discovered that in a vessel filled with water, in which the tropical plant *Pistia Stratiotes* was growing, evaporation took place six times as rapidly, or rather it evaporated six times as much water, as did a vessel of water of the same size in which no plant whatever was growing. This then is proof positive that plants absorb water, and that it is exhaled by them. Moleschott in his "CIRCUIT of LIFE," says that this evaporation is one of the most powerful causes of the absorption of elements in solution, by the roots of plants. Liebig says, "From the surface of young plants a constant evaporation of water takes place, the amount of which is in proportion to the temperature and surface. The numerous fibers of the roots supply the water which is evaporated, just as if they were so many pumps; so that as long as the soil continues moist, the plants receive, by means of water, the necessary constituents of the soil. A plant with double the surface of another plant must evaporate twice the quantity of water that the latter does. The water thus absorbed is expelled again in vapor, but the salts and constituents of the soil introduced to the plant by its agency still remain there."

I have never been fully persuaded that the view taken by Moleschott, Liebeg or Lehman, in this relation, is correct. It has always appeared to me that evaporation from surfaces

Digitized by Google

of plants was a consequence, rather than a cause—that it was the method adopted by nature to relieve the plant of an excess of moisture as well as a means by which effete matter is removed. How can evaporation take place from plants which have no evaporating surfaces? It is well known that the green parts of plants, leaves, buds and flowers are the only portions from which evaporation takes place; how then can *evaporation* in spring-time before the buds have swollen, be the cause of absorption of fluids from the soil by the roots, so as to cause the flow of sap? so as to cause grapevines if injured to bleed? But so far as the wheat plant is concerned, is it an established fact that evaporation takes place from the leaves, before the roots have absorbed fluids from the soil?

This theory of evaporation as the cause of absorption of fluids by the roots of plants advanced by Liebig, amplified by Moleschott, and partially although evidently hesitatingly indorsed by Lehman, while it is more plausible and really less objectionable than the theory of *endosmosis*, is perhaps equally distant from the truth, because it ignores any and all vital actions or participancy by the plant itself.

Considering the use that has been made of the known physical forces for explaining the absorption of liquids from the soil, the ascent of the sap, and also its descending course, Monsieur Trecul was surprised that no analogous experiment had been made in order to account for the absorption of the gases drawn from the atmosphere. Nevertheless, this latter faculty of plants, which authors have been content with indicating, is not less important than the absorption of liquids by the roots. But it has not been capable of explanation by the ordinary laws of physics. He attempts to prove that the inspiration by the roots, and the movements of liquids in plants, can not be effected under the influence of the physical forces to which such an important part is still ascribed, namely capillarity and endosmose. Even those physiologists who ascribe a great part in the ascent of the sap to capillarity, and especially to endosmose, are compelled to admit that they are

Digitized by Google

incapable of raising liquids to the hight of our trees, without the aid of the evaporation which takes place in the leaves, and which, as they say, draws the liquids toward those organs. If evaporation causes the liquids to rise, it must prevent them from descending: now they descend after arising; therefore evaporation does not assist in their elevation. I also think that Nature never makes use of insufficient causes like endosmose capillarity; and on the other hand, the part attributed to endosmose is incompatible with the constitution of plants.

Suppose for a moment, with the physiologists, that it is endosmose which causes liquids to rise by the ligneous mass, and afterward to descend by the bark. In order that this phenomenon should be accomplished, the density of the juices must constantly increase as they rise (this is what has been observed); and this density must also increase in passing through the leaves from the ligneous mass to the bark and in descending from cell to cell in the interior of the cortical tissue. We could not, moreover, recur exclusively to gravitation, seeing that there are pendent branches as well as erect ones.

The botanists who admit the endosmotic theory have not remarked that they have thus, side by side, two currents of liquids of different densities; they have not noticed that the ascending sap, being less dense than the descending, would necessarily be attracted by the latter, as the membranes are permeable; they have not considered that throughout the whole length of the trunk there would necessarily be a horizontal, centrifugal current, until an equilibrium of density was established, and that then the double ascending and descending current could not exist. As this is not the case, the endosmotic theory is erroneous. A force distinct from endosmose must therefore preside over the absorption of the liquids drawn from the soil, as well as over that of the gases taken from the atmosphere. And thus there are in plants other movements than that of the ascending and descending sap. This sap, in its course, gives off into all the cells the

Digitized by Google

substances necessary for their nutrition. These cells assimilate the elements which they require, and reject those which are useless to them. The rejected elements are taken up by the laticiferous vessels, or collected into peculiar reservoirs, like the essential oils, etc. These reservoirs, however, do not contain a liquid of greater density for which these essential oils have an affinity. Here again, therefore, endosmose has no part in the movement of the liquids.

The tendency to admit purely physical causes to explain physiological phenomena is again observed with regard to the spongiole; for this extremity of the root has been compared to a sponge, as is indicated by its name. Let us see, therefore, how far this comparison is exact.

The young tissues, the formation of which causes the elongation of the roots, are protected during their development by a sort of little cap, which for this reason are called pileorhiza. It actually envelopes the extremity of the root like a cap. This organ may be easily observed, especially upon the roots of aquatic plants, because in these the development is more rapid than in most other plants. This cap adheres to the extremity of the root by the interior of its apex; it is from this point that it is renewed, while its outer part, which is oldest, becomes destroyed. The external cells becoming disaggregated, could alone have given the idea of a little sponge. With regard to the power of absorption, which, at least in certain plants, is much stronger at the extremity of the root than in other parts of that organ, it evidently can not be assimilated to the capillary phenomena which cause liquids to rise in a sponge. The word spongiole, therefore, gives a false idea of that which really takes place in roots.

Some botanists who admit the spongiole, have nevertheless recognized the existence, on the surface of many roots, of prominent cells to which they attribute a share in absorption. In trees with a vigorous vegetation, such as the *Paulownia*, it has been observed in the spring, that the dead part of the bark was impregnated with a considerable quantity of liquid,

Digitized by Google

which would probably be yielded to the living parts of the root.

The liquids absorbed by the roots, by the agency of that force which we only know by its effects, namely, life, are conveyed into the ligneous mass of these organs, and thence into that of the stem. These juices rise into the leaves, and then they descend toward the roots describing a sort of circle. As they pass through the whole extent of the plant, I think it would be advisable to call this the great circulation, and to give the name of venous circulation to that which, by the laticiferous vessels, conducts the substances which the cells have not assimilated to the true vessels. There is also an intracellular movement which has been observed in many vegetables. This movement has received the name of rotation, because the juices appear to turn upon themselves, with more or less regularity, in the interior of each cell.

During the life of a plant all the liquids are in motion in each of the utricles of which it is composed, either to carry into these the elements necessary for their growth, or for the formation of the amylaceous, saccharine or albuminoid principles, etc., to which they give origin, or to remove from them those substances which have become useless, and which require to be eliminated, or those which have to be carried to other parts of the plant to serve for the multiplication of the cells and the growth of the individual. It is this general movement that constitutes the circulation; but this name is usually given to definite currents, more perceptible than this general intracellular movement, which traverse the plant through its whole length from top to bottom, and from the bottom to the top.

It is to this double current that the name of the *great circulation* is given. The *venous circulation* takes place, as above stated, in the laticiferous vessels.

The great circulation is observed in all vascular plants; but the laticiferous vessels have not yet been detected in all plants which possess vessels.

Digitized by Google

The great circulation, therefore, consists of an ascending current of the sap, and of a descending current. The ascending current takes place in the vessels which receive and elaborate the juices drawn from the soil by the roots. When this ascent commences, all the cells are at work. The nutritive substances which they contain arrange themselves by assimilation. Starch, dissolved, no doubt, by diastase, and converted into sugar, as has been stated on a previous page, is carried to the parts where the cellular multiplication is to take place. The starch of the base of the buds serves for the alimentation of the latter; that of the bark passes into the internal cells of that part of the plant, which very probably also receives some by the medullary rays. It is under the influence of these nutritive materials that the increase in diameter by the multiplication of cells commences. This multiplication at starting really takes place without the aid of the sap elaborated by the leaves, for in many of our trees the layer of young cells (generative layer, also called cambium) acquires a considerable thickness before the appearance of the leaves.

These first phenomena make their appearance with the ascent of the sap. This, in rising, undergoes an elaboration with which we are not sufficiently acquainted to speak of at greater length; I shall content myself with indicating the beautiful experiments of M. Biot, which have shown us the changes which sugar undergoes during the progress of this sap. During its ascent it already contains assimilable principles which may assist in the nutrition of the leaves and buds (in which the spiral vessels make their appearance from below upward); but in the spring these buds are indebted for their first development, especially to the alimentary substances amassed in the neighboring cells.

The sap, which on its way takes part in the nutrition of the first organs developed, arrives in the leaves, in the green parenchyma of which it is submitted to a fresh elaboration, or in the chlorophyll-cells of the stem of the fleshy plants

Digitized by Google

destitute of leaves. The carbonic acid of the air is absorbed and then decomposed during the day; its carbon is retained by the sap, and its oxygen in great part rejected. The sap, thus modified under the influence of respiration, takes its course through the cortical cells which it nourishes. It then aids in the multiplication of the cells of the generative layer, which are produced in horizontal series. A portion of these cells thus horizontally multiplied forms a new layer of bark, the woody fibers and medullary rays; the others are converted into vessels in the following manner. The excess of the descending sap which is not employed in the nutrition of the newly formed cells, or in thickening those first developed, descends through certain of the newly formed cells; it dilates them, perforates them, and makes them take all the characters of vessels, so that these cells, which, during the first phase of their development, resembled all the others, appear subsequently to be of a totally different nature.

It is this vascular formation which takes place, as we see, from above downward, at the expense of cells originating from a multiplication in horizontal series, that has led the authors of the theory of descending fibers to believe that these vessels, of which they did not recognize the nature, were true roots of the buds or leaves.

But all the sap absorbed by the old or new cells, whether for their increase in size or thickness, or for the production of starch, albuminoid substances, etc., which are to serve for subsequent growth, is not used up by the cells. These only assimilate a part of its elements and reject the rest. It is this *caput mortuum* which, in the form of resins, essential oils, etc., is collected in peculiar reservoirs, from which it is afterward thrown outwards;* or the unassimilated matters are taken up by the laticiferous vessels, which carry them back

* It is undoubtedly emissions of this nature and of this origin that constitute what are called the excretions of the roots, which agriculture seeks to turn to account in the rotation of crops.

Digitized by Google

into the vessels properly so called (this is the *venous circulation*). There these substances, which are usually destitute of oxygen, are elaborated and oxidized by the action of the oxygen derived from the air, which penetrates even to the vessels by intercellular passages; they become again fitted for assimilation. It would be from their oxidation, as I have already stated, that the carbonic acid rejected by plants during the night would be produced; that which is produced during the day being decomposed on its passage into the leaves under the influence of light, its oxygen is poured out into the atmosphere, together with that arising from the decomposition of the carbonic acid taken directly from the air by respiration.

All these facts prove evidently that it is the circulation which produces the vessels, that is to say, it is the function which creates the organ.

Since the circulation exists before the vessels, when there are only simple cells through the walls of which the sap filters, the objection made by some anatomists to the existence of the circulation in the laticiferous vessels, an objection founded on the cellular structure of these vessels in certain plants, does not possess the importance which they assign to it, as we see the dotted and striped vessels, etc., formed by a current of sap pre-existing through imperforate cells; and, moreover, these anatomists should consider that there is not a living cell which is not traversed by juices, although the great majority of these cells do not present any perforation visible by means of our most powerful microscopes. And then there are laticiferous vessels which are evidently composed of superposed cells, the transverse partitions of which present very wide apertures.

What is the precise function of the main root (C, fig. 8), whose appearance is the first obvious evidence of successful germination, is not known; but it is tolerably well ascertained that it is entirely absorbed immediately after the rootlets have commenced the process of absorption. From the discoveries fully stated on a previous page (see ante, on Germination), it

Digitized by Google

is highly probable that the rootlets convey to the capsules (E E E, fig. 8), a solvent fluid, or vegetable gastric juice, which fluid solves such inorganic substances as can not resist its solvent properties, and the *new* mass is then taken up by the capsules or spongioles which are found at the *termini* of every root and rootlet, and also by the absorbent cells ever formed at the extremities of the numberless suckers, for it is at these points that Mr. Osborne found the cell structure ever greedily taking in whatever of foreign matter he succeeded in introducing into the *media*, in which the plants were grown. Mr. O. distinctly states that he could not trace any circulation in the roots toward the crown or origin of the root, but distinctly traced a circulation toward the capsule on the extremity of the rootlet.

This gastric juice or solvent fluid may consist chiefly of carbonic acid, which is very essential to the growth of plants and has been fully detailed in the chapter on germination, is found to exist in the albuminous body of seed immediately after germination has commenced. A statement has already been made enumerating the different inorganic or elementary substances which enter into the composition of the wheat plant; in order to exhibit the tenableness of the solvent fluid hypothesis, it will be necessary to illustrate the affinity for or solvent power of carbonic acid over the elementary substances.

The air which we inhale is composed of oxygen and nitrogen, but what we exhale, or which is returned from the lungs, is composed of carbon and oxygen, or carbonic acid. Carbonic acid is given off from various substances in the course of decay, and it exists in the atmosphere as a product of combustion—for the burning of coal, wood, or any other substance produces carbonic acid. It exists in very considerable quantities in the mineral kingdom, combined with metallic oxides; also in all spring and river water, either in combination with earthy and alkaline bases, or dissolved in the water in an uncombined state. In volcanic districts carbonic acid

Digitized by Google

issues from the ground from the fissures or crevices caused by eruptions or earthquakes.

Carbonic acid is also the production of fermentation and putrefaction. Carbonic acid being thus generally diffused throughout nature, is continually being introduced into the soil by rains. Substances containing a large proportion of carbon are excreted by the roots and absorbed by the soil; in this manner the soil receives the greater part of the carbon it had yielded as food to the young plants in the form of carbonic acid. After the removal of a crop of annual plants, their roots remain in the soil, and there undergo putrefaction, thus furnishing a substance which will yield carbonic acid to a new vegetation. The decay of woody fiber converts a volume of oxygen gas into an equal volume of carbonic acid; —the "woody fiber in a state of decay is the substance called HUMUS," and is a continued source of carbonic acid. Humus or vegetable mold therefore does not nourish plants by being assimilated in its soluble state, but by furnishing a gradual and continual source of carbonic acid, which is the chief nutriment to the roots of plants, and is renewed as long as the soil admits the free access of air and moisture—these conditions being necessary to effect the decay of vegetable matter.

The sources just enumerated furnish an ample supply of carbon for all the purposes of vegetation. A contrariety of opinions have long prevailed as to the manner in which plants are supplied with carbon. It is a favorite theory with some vegetable physiologists to attribute the supply as having been received entirely from the atmosphere, through the medium of the leaves. However plausible such a theory may be, it does not explain all the phenomena of vegetation which its advocates claim for it. It is very evident that young and growing plants have obtained their full proportion of mineral substances from the soil, from the fact that equal quantities of young plants yield twice the amount of ashes that matured plants do. Saussure found that wheat one month before blossoming yielded $\frac{73}{1000}$; when it blossomed $\frac{64}{1000}$, but after the

Digitized by Google

ripening of the seeds it yielded only one-half this quantity of ashes. If, then, the theory be correct that plants obtain all their carbon from the atmosphere, it will be difficult to explain how plants should be affected by drouth, since they have already received all they require, according to this theory, from the soil, and carbonic acid is rather more abundant—in the opinion of another set of advocates—before than after storms or rains, so that the plant can inhale or absorb from the atmosphere all the carbon, nitrogen and oxygen requisite to elaborate and assimilate the mineral food. Lehman, the celebrated physiological chemist, says: "The first origin of *carbohydrates* which we meet with in their more advanced stages of development, as dextrine, sugar, starch, and cellulose, has, with apparent correctness, been referred to the decomposition of carbonic acid under the influence of light." But experience teaches that however abundant carbonic acid may be, if there is a long continued absence of rain, that plants droop, wither and die, and will not produce the starch, sugar, etc., in the seeds, which they would under the influence of genial rains, and an adequate supply of carbonic acid, from and through the roots. Liebig, however, is not perfectly satisfied that plants receive more than one-fourth of the necessary amount of carbon from the atmosphere; for he says: "Young plants, when dependent on the air alone, can only increase their amount of carbon according to their absorbing surfaces. But it is obvious, if their roots receive, by means of humus, *three times* the amount of carbonic acid absorbed by their leaves in the same time, their increase in weight will be four-fold, on the assumption of the existence of all the conditions for the assimilation of the carbon. Hence four times the quantity of stems, leaves, and buds must be formed; and by the increased surface thus obtained, the plants will receive in the same degree an increased power of absorbing food from the air." In the case of drouth affecting the plants, the difficulty will not be removed, when it is asserted that notwithstanding the plants receive all their carbon from the atmosphere, they receive

Digitized by Google

nitrogen, hydrogen, and oxygen from the roots; because it must be apparent to every one that it is more probable that these last named gases are absorbed from the atmosphere than that carbonic acid is; and it is somewhat inconsistent to assert that the heaviest gas is absorbed by the leaves from the atmosphere, while the lighter one are absorbed by the roots from the soil.

Finding the theory of supplying the plants with carbon from the atmosphere untenable, Prof. Henfrey * offers the following, no doubt in a spirit of conciliation: "Since it is evident that if the different external organs, such as the leaves, stems, and roots, can *all* exercise *any* of the functions of vegetable life, the general anatomy or study of external form can be of little use in guiding us, and we must make ourselves acquainted with the characteristics of the elementary tissues of which any given organ is composed. To illustrate this, we are not liable to mistake when we say that in man and the higher animals respiration is performed by the lungs. We could not say in the same general way that the leaves constitute respiratory organs of plants, for this function is not only ordinarily performed in part by the green shoots of the stem, but in some cases, as in the Cacti, the leaves are represented by hard spines, and the stem assumes entirely the respiratory function; and yet the Cactaceæ belong to the higher class of plants. Again, the stomach and intestinal canal of animals in general are the organs for the absorption of food; and this function is only combined with others when the whole organization is very low in the scale; but in plants we not uncommonly see the roots assuming additional or different functions, even in the highest forms of vegetable life; for in the turnip, carrot, and other analogous plants, the root becomes the organ not simply of absorption, but for the deposition and temporary preservation of assimilated food."

This statement, from the pen of Prof. Henfrey, is the more valuable because he is not only Professor of Botany in King's

* Royal Agricultural Journal, Vol. XVII.

Digitized by Google

College, London, but is one of the best vegetable physiologists of the present day.

With the reluctant admission of Liebig that three-fourths of the carbonic acid required by the plant is obtained through the roots, and the positive statement of Henfrey that the leaves are not *always* the respiratory organs, and even if they were, respiratory organs are not organs of nutrition; there is little hazard in asserting that the chief source of carbonic acid, of which the plant directly avails itself, is that obtained from the soil. But if there are any who think the assertion heterodox, and not sustained by any respectable authority, I will again quote Liebig. "A soil in which plants vegetate vigorously, contains a certain quantity of moisture indispensably necessary to their existence. Carbonic acid, likewise, is *always* present in such a soil, whether it has been abstracted from the air, or has been generated by the decay of vegetable matter. Rain and well water, and also that from other sources, invariably contains carbonic acid. Plants, during their life, constantly possess the power of absorbing by their roots moisture, and, along with it, air or carbonic acid."

Besides, it is an incontrovertible fact, that plants require mineral substances as food and these are furnished it through the roots in the form of solutions. On a previous page mention has been made of the formation of clays from feldspar; it is a well ascertained fact that water saturated with carbonic acid readily solves feldspar, so also, all minerals and rocks containing silicates of alkaline bases, are incapable of resisting the continued solvent action of carbonic acid dissolved in water. The alkalies with lime and magnesia will either dissolve alone, or the former will enter into solution along with silica, while the alumina remains behind, mixed or combined with silica. Phosphate of lime is soluble in water containing carbonic acid. Carbonic acid in the soil then, is capable of solving and holding in solution potash, soda, magnesia, lime, silica and alumina. Is it not, therefore, exceedingly probable, if not absolutely certain, that because carbonic acid solves

Digitized by Google

these elements and holds them just in the condition to be absorbed and assimilated by the plant through the roots, that the roots at the same time absorb the necessary amount of carbonic acid? What evidence is there that the roots absorb the minerals in solution and reject the carbonic acid, when it is not denied by any vegetable physiologist, that the roots absorb indiscriminately every fluid substance presented to them?

It is well known that the seeds of all cereals are chiefly composed of starch, that is, carbon, oxygen and hydrogen, as organic elements. If plants derived their carbon from the atmosphere, there would be no difficulty in obtaining perfect seeds from plants grown in water; but experience does not confirm this supposition, for however well the plants may grow in water, they rarely bloom, and when they do, they never produce seed. Liebig says: "The food contained in the atmosphere does not suffice to enable these plants to obtain their maximum size in the short period of their life. If the object of this culture is to be obtained, there must be present in the soil itself an artificial atmosphere of carbonic acid and ammonia, and this excess of nourishment which the leaves can not get, must be conveyed to corresponding organs existing in the soil."

The chief arguments which have been presented to sustain the position that plants derive their carbon directly from the atmosphere, through the agency of the leaves, are rather inferential and negative than otherwise. One of them is, that because plants exhale carbonic acid at night, they consequently inhale it during the day, but it might, with the same propriety be inferred that because the moon shines or gives out rays of light at night, that it absorbs or collects them during the day, to dispense again at night. The fact is that it requires light to fix the carbon in the plant, which has been absorbed by the roots and leaves or other green parts. When daylight ceases then the decomposition of the carbonic acid is interrupted—during daylight carbon was retained and oxygen

Digitized by Google

given off (it will be remembered that carbonic acid consists of carbon and oxygen), but when darkness takes the place of light, then the carbonic acid is not decomposed, but escapes every moment through the leaves, and as soon as daylight is again ushered in, the decomposition commences and the carbon is retained and fixed by the influence of light—similarly, perhaps, in many respects as the *shadow* is fixed on the sensitive plate in the daguerrean's hands—while the oxygen is excreted.

Another argument presented by the theorists who hold that plants obtain all their carbon from the atmosphere through the leaves, is the well-known experiment of a plant having been grown in a tub filled with soil, and at the end of a certain time the plant grew to be a tree weighing considerably more than the entire soil did at the commencement of the experiment, while the soil itself appeared to have diminished in weight a few pounds only. Now this experiment fails to prove that for which it was instituted. The plant was not watered with distilled, but with spring or brook water, neither was the soil so inclosed as to exclude dust, insects, and excrements from birds, etc., from accumulating on it. The plant received from rain and by artificial watering, all the alkalies which were not in the soil, or which had been exhausted, as well as the necessary amount of carbonic acid. Sea water contains less than one ten-thousandth part of its weight of carbonate of lime, and the phosphate of lime in sea water is so small that its amount can not be determined in a pound of the water, yet this exceedingly minute quantity, seems to be an ample store, and furnishes the material for the habitations of the myriads of marine mollusca and corals, and for all those phosphates found in the flesh and bones of all the living animals of the ocean. It is almost superfluous to repeat here that the water of brooks and springs, as well as well water, contains many alkalies as well as carbonic acid in solution; and that the roots of the plants are constantly engaged in

Digitized by Google

absorbing them. Hence the carbon as well as alkalies, of which the tree in question was composed, were conveyed to the roots in solution in water, and the experiment affords no proof whatever that the carbon was inhaled through the leaves.

On a previous page it was mentioned that the pungent smell in stables, in which horses and cattle were kept, was entirely due to ammonia. If the places where the urine and manure drop from the animal in the stable be occasionally sprinkled with plaster of Paris the offensive smell will vanish, while none of the ammonia will be lost, but will be condensed by the plaster of Paris. The ammonia in stables is always found in combination with carbonic acid;—the ammonia enters at once into combination with the sulphuric acid contained in the gypsum, or plaster of Paris, forming sulphate of ammonia, which is identical in composition with a substance which occurs native, and is known as *mascagnine*, and which is an efflorescence upon recent lavas—its composition being sulphuric acid 53.28, ammonia 22.81, water 23.91. The carbonic acid of the ammonia combines with the lime and forms a carbonate of lime. These newly formed compounds are entirely destitute of volatility and consequently of smell.

Every clay that turns red when burned contains ferruginous or iron oxides; the ammonia absorbed by clays of this character, is separated by every shower of rain, and conveyed in solution to the soil, in which form it is imbibed by the roots of the plants. When ammonia in the form of salts as *mascagnine* above described, or other salts, is applied to the soil not the least portion of it is lost to plants, because it is soluble in water, and hence readily imbibed and assimilated. Mulder, however, conjectures that ammonia passes into plants in combination with organic acids.

It has long been suspected that ammonia yielded nitrogen to plants, but since ammonia has been found to exist in every portion of the plant, this view has become somewhat modified.

Digitized by Google

It exists in beet roots, in the sap of the maple tree,* and in all blossoms and fruit in an unripe condition.

On a preceding page a statement has been made of variable quantities of gluten found in different varieties of wheat, as well as in the same varieties grown under different circumstances. Gluten is found by analysis to consist of—

Carbon 53.27.
Hydrogen 7.13.
Nitrogen 16.04.
Sulphur 23.62.

Proust found wheat to contain 12.5 per cent. of gluten; Vogel found Bavarian wheat to contain 24 per cent.; Davy obtained 19 per cent. from winter and 24 per cent. from summer wheat. He found that wheat from Barbary contained 19 per cent., and that from Sicily 21 per cent. of gluten. Boussingault found that wheat grown in Alsace contains 17.3 per cent.; that in the "*Jardin des Plantes*" 26.7, while the standard winter wheat contained 33 per cent. of gluten. It once was thought that the different proportions of gluten found in plants was entirely an inherent quality of the particular variety of wheat, but more recent investigations and experiments seem to warrant the conclusion that it is due to the different methods of cultivation and soils, rather than being an inherent quality in varieties; although, perhaps, each of the causes enumerated, contribute toward producing such a result. It is

* In the year 1834, I was engaged with Dr. Wilbrand, Professor of Botany in the University of Giessen, in an investigation respecting the quantity of sugar contained in different varieties of maple trees, growing upon unmanured soils. We obtained crystalized sugars from all, by simply evaporating their juices, without the addition of any foreign substance; and we unexpectedly made the observation, that a great quantity of ammonia was emitted from this juice when mixed with lime, in the process of refining, as practiced with cane sugar. The vessels which hung upon the trees in order to collect the juice were watched with the greatest attention, on account of the suspicion that some evil disposed persons had introduced urine into them, but still a large quantity of ammonia was again found in the form of neutral salts.—*Liebig.*

Digitized by Google

a well known fact in agricultural chemistry, that animal manure not only increases the number of seeds, but produces a most remarkable difference in the proportion of nitrogenous substances, one of which is gluten.

Liebig gives an account where "One hundred parts of wheat grown on a soil manured with cow dung (a manure containing the smallest quantity of nitrogen), afforded only 11.95 parts of gluten, and 62.34 parts of amylin, or starch; while the same quantity grown on a soil manured with human urine, yielded the maximum of gluten, namely 35.1 per cent., or nearly three times the usual quantity. The conclusion is, that it is an ammonia which yields nitrogen to the vegetable albumen, which is the principal azotized constituent of plants. The vast importance of nitrogen may be inferred from this fact, namely, we may furnish a plant with carbonic acid, with humus; in short, with all the necessary elements, but if nitrogen is withheld, it will not attain complete development; an herb will be produced, it is true, but it will not produce any flowers, but even if it does produce flowers it will not produce seeds, and although starch and even sugar may be produced, it will be found that gluten is entirely absent.

Notwithstanding the importance assigned to nitrogen in agricultural chemistry, there are occasional indications observable among leading authorities of dissatisfaction with the nitrogenous theory, that is, the universally received views of the part borne by nitrogen in the economy of plants derived from observation of the indisputable use and necessity of ammonia in vegetable nutrition. Hence it seems to be assumed that nitrogen is the one indispensable element of ammoniacal manures on which their intrinsic value depends; and to such an extent has this idea occupied the ground of scientific discussion, that the terms ammoniacal manures and nitrogenous manures are almost used as convertible terms. But these views are found to be attended with certain awkward and untractable anomalies, and the facts of nature refuse to accommodate themselves to the preconceived opinions of men. One of the

Digitized by Google

eminent agricultural authorities expressed on one occasion the conclusion his observation led him to in these words: "Wheat is a great waster of ammonia." The proposition, no doubt, was a consistent and legitimate consequence of his views as an advocate of the nitrogenous theory; for it expressed the only conclusion he could draw from the fact, that the wheat refused to account for all the nitrogen it had somehow made away with; but it sounded strangely impugnatory, as if Nature, which does nothing in vain, had constituted wheat, or any other plant, with a strong avidity for ammonia, for the useless purpose of wasting it or of taking it in, only to decompose and give out again. More lately Mr. Lawes and his coadjutors in the same field of agricultural science have come forward, and by a precise and philosophical deduction from carefully conducted experiments, have helped to confirm and extend the anomalous and inexplicable circumstances connected with the nitrogenous theory; for they tell us, as the result of their experiments, that while some plants failed to account for more than a small portion of the nitrogen that had been consumed, or otherwise disposed of, there were others which returned (in their composition, I presume) more nitrogen than had been supplied to them. Facts like these can not be otherwise than perplexing and inexplicable on the prevailing views of the part borne by nitrogen in vegetable economy; but they are quite in accordance with, and might be legitimately deduced from opinions expressed on the use and purposes of ammonia in vegetable economy, the purport of which was to prove that the appetence or avidity for ammonia, characteristic of vegetable life, is due, not to the nitrogen so much, as to the hydrogen of the ammonia, which all plants require to form, in conjunction with carbon, the substance of their physical structure; in other words, to form vegetable fiber, or hydro-carbonaceous matter, which is the basis of every part of the vegetable structure, root, stem, leaves, flower, fruit, seeds, and their envelopes of every form or variety; while nitrogen is only a variable and partial ele-

Digitized by Google

ment in plants, not entering at all into the chemical composition of vegetable fiber, and scarcely found in some vegetable substances, and more abundant in others; dependent entirely on the idiosyncrasy, so to speak, or physical peculiarities of each class or kind of plants, as bestowed on them by Nature for special purposes. Hence the requirements of plants for nitrogen will be as various as their physical peculiarities, and will be indicated and measured by the amount of nitrogen found in the composition of their substance and products, while all will exhibit pretty nearly an equal avidity or capacity for ammonia; and hence this discrepancy between the universal capacity of plants for ammonia, and their partial, and, generally speaking, very limited requirements of nitrogen, the first showing that there is something in ammonia they can not do without, and the other that that something is not nitrogen.

It appears to me that nothing more is necessary to arrive at a satisfactory solution, and at just views of the *primary* use and purpose of ammonia in vegetable economy, than to compare the chemical constituents of plants with the acknowledged sources or materials of vegetable aliment. These, with phosphorous and mineral substances, are water, carbonic acid, and ammonia, and humic acid, containing the four elements of the two latter substances. The following are a few of the most common and abundant substances in plants, with the proportions in which the elements of carbonic acid and ammonia are found in them:

	Oxygen.	Carbon.	Hydrogen.	Nitrogen.
Lignin, or vegetable fiber.....	42.25	52.00	5.75	00.00
Starch.....	49.68	43.55	6.77	00.00
Gum.....	50.84	42.23	6.93	00.00
Sugar.....	50.63	42.57	6.90	00.00
Wax.....	5.48	82.19	12.33	00.00
Gluten or vegetable albumen.....	25.13	53.40	6.80	14.67

Digitized by Google

The first conclusion to be drawn from the above is, that plants require no nitrogen for the formation of vegetable fiber, the substance or basis of their common structure. This then is a very extensive reason, embracing by far the largest portion of vegetable matter, why plants, generally speaking, must fail to return or account for the nitrogen which has disappeared in their consumption of ammonia, and it is irrespective of a large and abounding class of vegetable products, as starch, gum, sugar, wax, oils, etc., which have not a particle of nitrogen in their composition, and therefore do not require it for their production. The next conclusion is suggested by the regular occurrence in certain proportions of hydrogen in all vegetable substances, not excluding gluten itself, the chief storehouse of nitrogen in the vegetable world; and it seems to point out very clearly what use is primarily made of ammonia by plants. When an eminent agriculturist made the observation before adverted to, that wheat is a great waster of ammonia, was there really any waste of it? A great deal of nitrogen had certainly disappeared, but had the hydro-carbonaceous matter of the entire plant contained in the vegetable fiber, the starch and gluten itself been estimated, instead of the partial amount of nitrogen in the latter substance, it must have been apparent that the wheat had made a very good use of the ammonia, though in a different direction from what his mind had been contemplating.

There is a somewhat remarkable circumstance connected with the chemical constitution of vegetable substances, which deserves the attention of those who consider the production of vegetable fiber, sugar, etc., as a chemical combination of carbon and water; from the circumstance of oxygen and hydrogen existing in those substances, in the same, or nearly the same proportions as in water. This view may be disproved by other arguments; but the point to which I now advert is, that a more steady and intimate relation subsists between the proportions of carbon and hydrogen, than between those of any other two constituents of vegetable sub-

Digitized by Google

stances. This will be seen by referring to the above list, and is more particularly exemplified in the case of wax, oils, resin, etc., in which, while the proportion of carbon rises to nearly double of what it is in sugar, starch and gum, the hydrogen rises along with it in nearly the same proportion, and an equivalent amount of oxygen is displaced. Again, in gluten it will be seen that while the carbon and hydrogen exist in proportions not materially different from what they do in vegetable fiber, the nitrogen is interposed at the expense of the oxygen. Now, setting aside the consideration that we have no proof that plants chemically decompose water, and that they appear merely to absorb it in its natural state, as the solvent and vehicle of those alimentary particles from which their substance and products are formed, should we not expect if vegetable fiber, sugar, etc., be really produced from a chemical combination of water and carbon, that there should be as close and constant a relation between the proportions of oxygen and hydrogen in all other substances of vegetable origin, as in these? Should not the type of relationship in vegetable substances be hydro-oxygenous rather than hydro-carbonaceous, as we see that it is. Or, to avoid this difficulty, must we resort to the still more untenable position, that though vegetable fiber, sugar, etc., are formed by a chemical combination of carbon and water, other vegetable substances are formed in some other way? The hydro-carbonaceous relation, for such it really is, which is characteristic of substances having a vegetable origin, when taken in connection with the admitted requirements of plants for carbonic acid and ammonia, presents a much more natural and satisfactory explanation of the sources and manner of their production, in agreement with their chemical constitution, and with known facts in vegetable physiology. In the two substances just mentioned we have the four elements, which enter into the composition of vegetable substances. Two of them, carbon and hydrogen, are universally necessary, and are found combined in proportions varying from eleven to twenty parts

Digitized by Google

of hydrogen to one hundred of carbon in different substances. Of the other two, oxygen appears to be universally present in vegetable substances, but in strongly unequal qualities, varying from nearly twelve parts of oxygen to ten of carbon in sugar, down to one part of oxygen to fourteen of carbon in wax. Nitrogen, though stored up in considerable quantities in particular parts of various plants, forms a component part of comparatively few vegetable substances, the chief being gluten, and something very nearly the same, frequently termed in chemical analysis as vegeto-animal matter: in gluten, nitrogen stands in the proportion of about twenty-seven parts to one hundred of carbon. If one might draw a distinction between the relative places and functions of these constituent elements, the two former, carbon and hydrogen, might be regarded as the fundamental or constructive elements of vegetable matter, and the two latter, oxygen and nitrogen, as their modifying elements; the diversified qualities of vegetable substances appearing mostly to depend on the extensively varying proportions in which these two elements enter into their composition, and little on variations in the proportions of carbon and hydrogen, which, as we have seen, are limited to a very small range. When carbonic acid and ammonia are presented to plants in conjunction with water, and the presence in the soil of mineral and other substances suited to their nature and requirements, the latter are in a condition to decompose them, and by a new arrangement of their component elements, to convert them into the materials of their own substance and structure, and of the various products, which an all-wise and beneficent Creator has conferred on them the power of elaborating. But they can only do this by combining these elements in certain definite proportions; and both carbonic acid and ammonia contain more oxygen and nitrogen than the requirements of plants, generally speaking, render needful; consequently, while they make use of the entire carbon and hydrogen which these substances contain, there is much of the oxygen of the carbonic acid and of the nitrogen of the

Digitized by Google

ammonia which they can not usefully appropriate: they, therefore, reject or give out the excess of these elements, which mix with and form component parts of the atmosphere. This is consistent with what has long been known respecting plants giving out oxygen; and the experiments and researches of M. Ville, establish the fact that plants also respire or give out nitrogen.

Gluten, or vegeto-animal matter, represents the most common form or combination in which nitrogen occurs in plants; and it exists in them in very variable quantities and in partial states; perhaps entirely wanting in some, in others a mere trace of it, and in others again more or less abundant: not generally found diffused through every part of a plant, but concentrated or stored up in some particular parts or products, as in the seeds of wheat, peas, beans, lentils, acorns, chesnuts, etc., in various fruits, and sometimes in the leaves of plants, as cabbage, cress, etc.; and it mostly occurs in those plants and their products which constitute the food of man and animals, showing its obvious use and intention. From the partial existence then of nitrogen in plants and vegetable products, and, speaking generally, the very limited capacity they have of appropriating it, it is only to be expected that plants should ordinarily fail to return the amount of nitrogen supplied to them either through the medium of ammonia or in any other form; at the same time, this is not inconsistent with the supposition, that there are plants exceptionally endowed with an unusual capacity for appropriating nitrogen; and in these cases a greater amount of it may be retained in their composition than can be readily accounted for by special experiments, as seems to have been the result in Mr. Lawes' investigations.

The subject is one, not of merely speculative interest, but of practical importance. I believe considerable sums of money have at times been expended and thrown away from erroneous views of the primary use of ammonia in vegetable economy, proceeding on the supposition that nitrogen is the only or special element in it that renders it useful to plants; hence

Digitized by Google

nitrate of soda, and perhaps other merely nitrogenous substances, have been often applied in agriculture at considerable expense, where at best they must have been useless, if not hurtful.

The following summary of results of examinations of winter wheat are condensed from "Jahrbuch der Akademie zu Tharand," by a A. Stockhardt, and exhibits clearly the part played by nitrogen:

1. Roots.

The *watery* contents decrease continually, during the development of the plant, being smallest in quantity at the time of flowering.

The *nitrogenous* contents increase at first, then decrease, but with considerable fluctuations, and are greatest about the time of the formation of the head (2.6 per cent.), and smallest at the time of ripening (1.15 per cent.)

The ashy contents increase until flowering, and decrease thenceforth until harvest-time; they are greatest at the time of flowering (16.4 per cent.), smaller at the time of ripening (11.02 per cent.)

2. Stalks.

The watery contents decrease continually, and are smallest in quantity about the time of flowering.

The nitrogenous contents increases at first, but from the time of flowering, when they have attained their maximum (3.1 per cent.), they decrease regularly until harvest, at which time they amount to 1.15 per cent.

The ashy contents correspond with the nitrogen in variation, being greatest at the time of heading (7.5 per cent.), and least at maturity (3.7 per cent).

3. Heads.

The watery contents decrease continually, most slowly at the time of flowering, most rapidly in the latter periods of

Digitized by Google

vegetation, and much more rapidly in the chaff (empty heads), than in the grains.

The nitrogenous contents diminish continually until after flowering, and are consequently greatest in the young heads still inclosed in the involucre (3.5 per cent). This diminution continues in the chaff after flowering (1.6 per cent.), but on the contrary the grains become somewhat richer in nitrogen until maturity (2.4 per cent).

The ashy contents increase somewhat regularly until after flowering (6.4 per cent). This increase continues in the chaff until harvest (9.4 per cent.), while a very considerable decrease occurs in the grains (1.9 per cent).

4. The Different Parts of the Plant collectively.

Every part of the plant shows at the beginning of the process of heading out, its maximum of nitrogen; the stalks containing the most, the ears less, and the roots the least. About the time of maturity, the different parts follow each other in regard to their content of nitrogen, thus: grains, chaff, stalk, root, the latter two being nearly equal.

The best refutation which I have seen of the theory that plants derive not only their carbonic acid, but their nitrogen, from the atmosphere, is the following, which is taken from an Essay on Agricultural Chemistry, published in the *Journal of the Royal Agricultural Society*, written by Liebig, in 1856, in defense of his views as misinterpreted by Messrs. Gilbert and Lawes, of England.

"Experience demonstrates that the produce of two fields in the same district are very unequal. One meadow yields twice, thrice, four times as much hay as another meadow of equal surface, under the same external circumstances. An acre of clover in one field yields twice, thrice, or four times as much clover as an acre of another clover field. There are fields, nay, entire districts, on which clover does not grow or grows but poorly. *What is the cause of this unequal fertility?* The surface of the fertile, and that of the unfruitful field, are in

Digitized by Google

contact with a precisely equal volume of air; to both, therefore are presented by the air and by the rain, precisely equal quantities of carbonic acid and ammonia; it is therefore plain that the cause of the difference of produce must be sought for, not in the atmosphere, but in the soil; this cause must be the inequality of the soil, while the external conditions are the same.

In the fertile soil, twice, thrice, or four times as much of the terrestrial elements of nutrition have entered into the plants, than in the unfruitful one. There have, therefore, been more of these terrestrial constituents present, either absolutely or as regards their capacity of assimilation (their power of entering into the plant, from their existing in available chemical forms) in the one soil than in the other. The amount of produce in these cases is unquestionably proportional to the quantity of mineral elements of nutrition present in the soils, and not to the quantity of carbonic acid and ammonia, for the atmosphere has supplied to both an equal quantity of these materials, but in the one soil the conditions of their conversion into organic compounds were efficient, or operative, or greater in quantity, during the same time than in the other.

Digitized by Google

CHAPTER IX.

EXPERIMENTS OF THE DUKE OF SALM HORSTMARR ON THE GROWH OF PLANTS IN INORGANIC ARTIFICIAL SOILS.

MUCH has been written on the function which inorganic matter has been supposed to perform in the growth of the plant;—many chemists have endeavored by the analyses of the ashes of different parts of the plant to determine precisely the purpose and office of each compound. It occurred to the Duke of Salm Horstmarr of Brunswick (Europe), that a more correct method would be to compose a soil of inorganic elements, all of which should as far as possible be prepared in an artificial manner—then by omitting in consecutive experiments a single element in each experiment, it was presumed that a more correct knowledge of the importance and special functions of each element would be obtained.

The following which I have translated from the German, embodies his experiments and results on the nutrition of plants. "In order to ascertain the inorganic nutrition of plants, it becomes necessary to select a medium which should be entirely free from any admixture of other inorganic elements. For this reason the carbon which I selected was obtained from the purest crystallized sugar; and to avoid any admixture of inorganic substances, it was thoroughly heated in a platina vessel. The experiments of Gærtner suggested the idea to me that plants would grow well in carbon. Small tin cups without any aperture in the bottom and coated on the inner surface with beeswax were the vessels used in the following series of experiments. The plants were watered with distilled water; the place in which the experiments were conducted was an uninhabited chamber, facing to the south; the plants were

Digitized by Google

placed on a fixture at the window, so as to enjoy the noon-day sun.

Experiments with White Oats.

The first experiment, the following composition and in the following proportions, viz.:

Carbon (of sugar)		2½ ounces.
The silicate of Potash was dissolved in 40 grms. of water.	Silicic acid	0.075 grms.
	Potash	0.03 "
	Nitrate of ammonia	0.05 "
	Nitrate of magnesia	0.03 "
Carbonate of lime		0.5 "
Carbonate of magnesia		0.05 "
Phosphate of lime		0.1 "
Sulphate of lime		0.1 "

In this composition the plant attained a hight of 25 inches, had five flowers which produced five imperfect fruit, incapable of germination. The blossoms were very delicate; the leaves of a pale color—yellowish green. The plant when dried weighed 0.37 grammes. I will now proceed to give the results of the first twenty-nine experiments with white oats:

Results.

In all these experiments made with a carbonaceous inorganic soil or rather a soil composed of inorganic elements, entirely devoid of all nitrogenous substances or ingredients, it was found that the plant not only grew, but actually grew better than with the addition of nitrogenous ingredients—besides the plant weighed four times as much in the former as in the latter case. But the plant in both cases was a frail pigmy, whose regular formation was very remarkable.

2. In that series of experiments in which no inorganic nor nitrogenous ingredients were added, a well-proportioned dwarf plant was the result; but in the experiment where nitrogenous ingredients were added, and other inorganic ones withheld, the plant was not well proportioned, but had leaves

Digitized by Google

of a very lively green, and were extraordinarily long; a single flower (blossom) was produced. Both plants when dry had the same weight.

3. In that series of experiments wherein *certain* inorganic ingredients were added, combined with nitrogenous ones, the plants were very thrifty. In an experiment with the same proportion of nitrogen, but an omission of the other inorganic ingredients, the plant died in the first leaf. When any one of the inorganic ingredients mentioned in the experiments which produced thrifty plants were omitted, then the plants died in an early stage of development; or if they lived beyond it, were very feeble, pale in color and their entire formation abnormal.

4. When a greater proportion of certain inorganic ingredients were added to the carbon of sugar, or coal dust of sugar, without reducing the amount of nitrogen mentioned above, the result was a powerful assimilation and increase of blossoms. From these experiments we were led to conclude that inorganic ingredients in combination with nitrogenous ones, must exist in the soil to produce normal and powerful plants, and that certain inorganic elements are essential to the plant as nutriment.

5. If we combine with the enumerated inorganic ingredients silicic, phosphoric and sulphuric acid, and potash, lime and magnesia only (together with the nitrogenous salt), we find that the plant grows more rapidly than without them, but it remains very pale, feeble and abnormal.

6. But if we combine with this mixture a very small quantity of oxide of iron, then we find its effect upon the plant to be very surprising indeed—the plant now assumes a normal dark-green color, the leaves are of a luxuriant growth and proportionate strength; the whole plant has a healthy stiffness and robustness, and its weight is more than double that of one grown without the iron. Upon the whole the plant was abnormal; traces of dry spots were very manifest in the center of the leaves; the stalk and capsule gave indications of abnormal condition. An excessive proportion of iron

Digitized by Google

increased the desiccated spots in the leaves, and prevented the formation of flowers.

7. When a small proportion of carbureted oxide of manganese was added to the above named composition, a powerful plant was grown, which exhibited no signs of desiccation on the dark green leaves, but had a normally developed stem and powerful joints. Manganese appears to increase the assimilation of the plant; at all events the plant grown with manganese and iron weighed considerable more than without. But manganese produces an abnormity in the structure in the sheath of the last leaf, inasmuch as the latter appears to have turned on its axis, so as to render the breaking through, or expansion of, and the full development of the panicle difficult. In the stools or side shoots this abnormal condition was not manifest; hence the inference that it is caused by the quantity of manganese.

8. These experiments do not decide that soda is an *essential* ingredient, although its presence appeared beneficial, more especially when there is an excess of manganese, inasmuch as it removes the abnormity caused by the manganese in the sheath of the last leaf. But if there is no potash in the mixture, then the opposite result takes place, inasmuch as the soda not only strengthens the turning of the last leaf sheath, but makes the leaf itself appear wound or twisted.

9. Up to a certain point, soda appears to neutralize the potash, although uniformly at the expense of the plant.

10. Magnesia can not neutralize lime.

11. When phosphoric acid was omitted in the mixture, but silicic and sulphuric acid, potash, lime and magnesia retained, it was found that nitrogenous salts were much more effective, than when sulphuric acid was omitted and phosphoric added to the mixture. But in both these cases, although the plant was well proportioned, yet it was exceedingly weak. The one which was grown without phosphoric acid, by some extraordinary freak produced a perfect seed; on the contrary, the one which was grown with phosphoric acid, but the sulphuric

Digitized by Google

omitted, produced no fruit, although this acid enters very minutely into the composition of the plant or fruit. This to me indicates the importance of both these acids in relation to the assimilation of the nutrition of the plant. The importance of the sulphuric and phosphoric acids are more manifest when we compare the weights of the plants produced in these several experiments. The weight of the plant is found to be four times greater when both are present than when either is omitted.

12. When silicic acid was omitted, the plant did not stand erect, but reclined; it was a very smooth, pale, well proportioned dwarf.

When lime was omitted, the plant died in the second leaf. Without soda or potash, it attained the length of three inches.

Omitting magnesia, the plant remains feeble and *couchant*.

The plant was very weak and tender, although erect and normally formed when phosphoric acid was omitted.

It was weaker, although erect and well proportioned, but without fruit, when the sulphuric acid was omitted.

Without iron, the plant is pale, feeble and abnormal.

It will not attain its full strength, neither will it bloom profusely, without manganese. From these experiments with the carbon of sugar, it appears that: silicic acid, phosphoric acid, sulphuric acid, potash, lime, magnesia, iron, and manganese, are the ash-producing ingredients essentially necessary to produce the oat plant.

13. These experiments do not determine whether chlorine is, or is not essentially necessary in the production of this plant; although the carbonate of sugar was washed and the inorganic ingredients free from chlorine (except in the case of the experiment made with sal. ammoniac), yet in two cases in the water which was extracted from the plants grown in the sugar coal dust, there were decided traces of chlorine, although too small in quantity to be measured. This chlorine was not derived from that of the seed, for the reason that there is a still smaller quantity in the seed. The

Digitized by Google

distilled water with which the plant was watered was distilled rather rapidly.

I will state in conclusion another experiment made with the coal dust of sugar, namely, an experiment which was conducted in a cast iron vessel, and therefore contained oxide of iron and manganese. The inorganic ingredients were the same as in the first experiment, with this exception—to the coal dust was added some soda and chloride of soda. This experiment showed what ingredients were wanting in the others; because in this the plant was not only very vigorous, deep green, but bore five perfect seed grains, which successfully withstood the germinative test. Soda as well as iron, therefore, appear to be necessary in the formation of the oat fruit.

COMPARISON OF EXPERIMENTS WITH WHITE OATS, WHICH WERE NOT GROWN IN COAL DUST, WITH THE FOREGOING EXPERIMENTS:

These experiments were suggested by Alexander von Humboldt. They were made in the purest brook sand heated to a glowing heat, and combined with artificial silicic acid, and finally with rock crystal, so as to approximate somewhat to the natural soil. The inorganic additions were the same as in the preceding experiments, and the experiments themselves were conducted in the same manner—always omitting one of the component ingredients in order to test its effect or necessity. And here I would remark that basic-phosphorous oxide of iron, nitrate of soda, chloride of sodium, and nitrate of potassium, were added in several special experiments.

Cups made of filtered white wax, without any orifice in bottom or sides, were the vessels in which the experiments were made.

The result of these experiments may in brief be stated as follows:

1. In pure, well heated sand, without any inorganic or nitrogenous additions, the oat plant grew with normal structure and proportions, yet very small and tender.

Digitized by Google

2. The number of fruits were reduced to a solitary one, although the sand was not entirely free from silicates and traces of phosphorous oxide of iron. In the absence of nitrogenous combinations, the assimilation of all atmospheric ingredients is greatly retarded.

3. With the addition of nitrogen—but without any other inorganic ingredient—to this sand, which contained traces of silicates, the plant grew higher, bore one blossom and one fruit more than in the preceding case, but the stalk lost the power to stand erect. The same experiment in every respect made in pure, natural quartz, instead of brook sand, produced a plant with scarcely any stalk, and no flowers—the assimilation being apparently entirely prevented.

4. When nitrogen was omitted, but the following seven articles combined, viz., silicic acid, potash, lime, magnesia, oxide of iron, phosphoric acid, and sulphuric acid, the plant remained very small and feeble, as in the first experiment, the flowering force much reduced, and the capacity for producing fruit ceased entirely; but instead thereof there appeared to be a disposition to produce another stalk by the side of the first. The result of vegetation in this case is therefore abnormal. Assimilation goes on very slowly—is scarcely perceptible.

5. When these seven inorganic ingredients were combined with a nitrogenous one, and administered as nutriment to the plant in a proper manner, then was the growth of the plant not only normal, but vigorous, and the flowers very much increased in quantity, but a normal termination of vegetation did not take place, notwithstanding a great propensity to grow side shoots. In this experiment it was found that assimilation went on very rapidly; thus demonstrating that the conditions of its success have been discovered.

6. When any *one* of the above enumerated seven inorganic ingredients was omitted, although the nitrogen was combined with the remaining six, it was found that the proper development was disturbed in a greater or less degree, in the following manner: When lime was omitted, the plant died in the

Digitized by Google

second leaf, without giving any indication of forming a stalk.

Without magnesia, the stalk was not erect but couchant, feeble, color abnormal, the structure of the flowers changed, and the flowers deformed and without fruit.

Without potash the stalk was very short, feeble, couchant, color abnormal; flowers, reduced to a solitary one, and it very defective.

Without soluble silicic acid and without potash, the growth of the stalk was reduced to three inches, color abnormal, the leaves dying prematurely, and no flowers.

Without phosphoric acid, the stalk was very frail, couchant, color pale, flowers reduced to a solitary perfect one, no fruit, but a disposition to throw out side shoots.

Without sulphuric acid, no stalk formation—the plant died in the third leaf; a shoot was thrown out, but shared the same fate.

Without iron, the green color is wanting in a greater or less degree; the plant appears as though it were grown in a dark place—no flowers are formed, or else are very much deformed, and very defective. (When aluminum was supplied the plant seemed to suffer the loss of iron in a less degree—the clay, however, may have contained traces of iron.)

7. From this it appears that the above named seven inorganic substances are essentially necessary to the growth and development of the plant, even to the formation of the flowers, provided that the proper nitrogenous ingredients are present. These experiments do not, however, confirm the necessity of chlorine—in these experiments every accidental admixture with chlorine was carefully avoided by rinsing and cleansing; while the plants were watered with double distilled water; notwithstanding all this care, there were evident traces of chlorine in the plant, which could not possibly have proceeded from the seed, since there is not in a single seed sufficient chlorine to be detected.

These seven inorganic substances failed to produce fruit.

Digitized by Google

8. Sodium does not appear to possess the properties necessary to neutralize the potassium.

9. The greater portion of these results of experiments made in quartz and quartz sand, correspond very nearly with the results of experiments made with sugar coal. At the same time it must be remembered that the sand contained silicates, and contained very small proportions of phosphate of iron; the sugar coals on the other hand, were not altogether free from traces of inorganic substances, as subsequent investigations proved.

The experiment with the sugar coals, omitting all inorganic substances other than nitrate of ammonia, proved to be very different from a similar experiment with quartz sand. It is very evident from the roots of the plant, that in the sugar coal experiment, entirely too much nitrate of ammonia was employed. Experiments with both the above bases prove that the results are greatly influenced by the proportion of iron which enters into the composition.

10. Manganese does not appear to be essentially necessary for the formation of fruit, especially when too much iron has not been employed. The question of the essentiality of manganese was exceedingly difficult to be decided in the sugar coal experiment, while the more powerfully absorbing qualities of iron in moist coal dust, render the proper determination of the relative proportions yet more intricate; thus in all the coal dust experiments, manganese appeared to be essentially necessary on account of the presence of the iron. (For the same reason is manganese necessary in a soil which has a comparatively large per centage of iron. In some soils it is found not unfrequently amounting to fully one per cent.)

11. When iron is in excess, the growth of the stalk is abnormal, the leaves become dried with brown spots (iron spots) in various places (corresponding with the experiments in coal dust, with this difference, that in the latter experiment the color of the spots was varied). The flowers are imperfect and

Digitized by Google

dwarfed, and the fruit undeveloped. That iron is an essential ingredient in the soil, and that the plant requires an exceedingly small proportion of it, is manifest from the analysis of the ashes of a vigorous, normal and fruitbearing plant, produced in brook sand, which had been heated to a red heat, then digested in muriatic acid, and the necessary inorganic ingredients added afterward, with the exception of iron, a sufficient quantity of which was in the sand.

12. Phosphate of iron is found to be an excellent source of iron for the plant. When brook-sand is employed oxyhydrate of iron may be added; the quartz will soon be found to be tinged with a greenish cast, caused by microscopic algæ, which announce the operation of the oxyhydrate.

13. Fluate of lime dwarfs the growth of the plant, and prevents flowering, even when added in very small quantities.

14. But when the above named seven inorganic ingredients were combined with the nitrogenous ingredients and added to the quartz, it did not produce a normal growth of fruit. It was in the test experiment only, with heated brook sand digested in muriatic acid that proved an exception to the general rule, and proves also that the failure of the former to produce fruit, is by no means attributable to the season, for the reason that both experiments were conducted at the same time. This test experiment proves also, that the seven ingredients, together with the nitrogenous elements in this case did produce fruit—they should, therefore, have produced the same result in the quartz, but as they failed to accomplished it in the latter case, we must conclude that the brook sand contained an inorganic substance essentially necessary for the formation and development of fruit which was not contained in any of the added ingredients.

15. Alumina appears to be such a fruit-forming and developing ingredient as above mentioned; at least several experiments indicate such results. The experiment with hydrate of alumina produced two germinating seeds; that with artificial silicate of potassium and alumina produced two seeds having

Digitized by Google

germinating properties; so also resulted the experiment with feldspar from Baveno. The experiment with scolecit from Iceland—composed of silicic acid, lime, alumina, and water, soluble in a dilute acid—containing no trace of sodium, produced no fruit, which impairs the stress laid on the importance of silicate of alumina.

16. The experiment with three decigram. clay from Almerode (slightly heated) which, although it produced five germinating seeds, appears to have contained other and essentially necessary ingredients for the growth and development of the fruits, as the clay contained only about six centigrammes of alumina, and was not certainly any more soluble after being heated than was the hydrate of alumina in one of the former experiments, which produced fewer perfect fruits. The washed clay from Almerode contains, according to Forchhammer, aside from silicate of alumina, about 13 per cent. of potassium, manganese, iron, and traces of chalk, and undoubtedly traces of sodium. In 0.3 grm. of washed clay of Almerode, I found 0.0047 potassium and 0.0013 of sodium, therefore I am led to conclude that the sodium is the important agent.

17. The side-shoots or suckers merit special attention, as they appear to have an important relation to the formation and development of fruit. Whenever side-shoots made their appearance, it was invariably found to be after the vegetating period, as well as after the appearance of the fruit. They originate always either immediately before, or co-incident with the sterile flowers in all these experiments.

In the experiment with hydrate of alumina, as well as in the one with silicate of potassium and alumina, also in the one with the feldspar from Baveno, in each of which experiments two germinating fruits were produced, the side-shoots made their appearance after the plants were in bloom; and in the experiment which produced five perfect fruits, they attained a respectable size. On the other hand, in the experiment with three decigram. of clay from Almerode, which produced five

Digitized by Google

perfect fruits, and singular as it may appear, two small projections made their appearance as side-shoots *after* the fruit had fully ripened. But finally it must be observed that in all test experiments in brook sand, which produced six, eight, or nine perfect fruits, there were no traces of side-shoots. Now, if we take into account the proportion of flowers to the perfect fruits, in connection with the number of side-shoots, as follows:

Experiment.	Flowers.	Fruits.	Side-shoots.
1. Hydrate of alumina	7	2	2
2. Clay of Almerode	8	5	2 smallest.
3. Feldspath from Baveno	4	2	2
4. Artificial silicate of potassium and alumina,	6	2	2
5. Test experiment in brook sand	9	8	0
6. Same	8		8
7. Brook sand digested in muriatic acid	11	9	0

We find the proportion of Flowers in the 2nd case to be as 8 to 5
" " " " " Fruits " " 6th " " " " 8 to 6

The proportion in these two experiments are so nearly equal as to be remarkable, and to excite some surprise that in the case of the brook sand all vegetation ceases with the ripening of the fruit, but in the experiment with the 3 decigram. of clay from Almerode, mixed with quartz, vegetation did not cease with the ripening of the fruit, but produced after the ripening period two small side-shoots.

From this it would appear that the three decigrams of clay from Almerode, aside from the alumina, contained one or more inorganic substances which were essentially necessary to the formation of fruit, but not in sufficient proportion or abundance to produce a sufficient amount of fruit which should exhaust the normal vegetative power coincident with the ripening of the fruit.

18. The experiment with the three decigrams of washed clay from Almerode, which was heated in the open air, is one of singular as well as peculiar importance. It furnishes us

Digitized by Google

with the extreme proportion of inorganic substances contained in three decigrams of clay essentially necessary to perfect fruit—under these conditions. It is very clear that the energy or force of the elements were not exhausted in forming and perfecting the five fruits, from the fact that sufficient vegetative force and material yet remained to form two small side-shoots. If there had been a sufficient surplus of vitality or vegetative force, it would have found its way to, and have perfected the remaining two flowers; by referring to experiment 7, it will be seen that sufficient of the other inorganic elements were present.

19. A very singular phenomenon was exhibited in an experiment in well heated brook sand, which in addition to the usual addition of inorganic ingredients, contained chloride of potassium and carbonate of sodium. In this case the side shoots made their appearance at a peculiar period, namely, before the stalk which bore the fruit panicle was developed. This is precisely what takes place in practical agriculture when the oats are sowed on a rich and strong soil, and it is also found by experience that the fruit increases in proportion to these side-shoots.

From this it is very evident that 0.005 grms. of chloride of potassium, and 0.001 of carbonate of sodium, either singly or combined, produced fruit and side-shoots, because a cotemporaneous experiment was conducted in brook sand without these ingredients, in which the phenomenon of fruit and side-shoots did not take place. This experiment is important inasmuch as it serves to show that in either the chloride of potassium or carbonate of sodium the necessary elements for the formation and development of fruits are contained. But which of these two ingredients supplied the necessary material for fruits, future experiments must determine. It is remarkable, however, that when the experiment was conducted in pulverized flint, even with the addition of the above named two ingredients, no fruit was produced.

20. The appearance of side-shoots coincident with the

Digitized by Google

flowering period, or after the maturity of the fruit, is indicative of a total or partial want of the proper ingredients to form fruits. If this exponent were not strictly observed, the 1st and 2d experiments might serve to mislead rather than guide us correctly; because in these experiments we might be inclined to ascribe the fruit formative elements to the alumina; but upon a more minute examination it will be seen that the alumina is entirely inessential to this end. It is however, not only possible, but highly probable that a trace of sodium was contained in the alumina, or silicate of potassium and alumina, which alone was the cause of the formation of the fruit. No traces of sodium could be found in the ashes of the plants which were grown in alumina, from which all other elements had certainly been expelled.

As an annual plant, the oat must cease vegetating the moment its fruit has ripened, and when we shall have discovered the exact proportion as well as the precise number and quality of the ingredients to produce this result, we shall have attained the object of these experiments.

21. A small, clear drop or globule resembling dew was formed on the end of the first leaf, at the time of its first appearance, but as the leaf became more fully developed the globule disappeared. It was found on the first leaf only. It made its appearance daily just after sunset, but during the night increased somewhat in size, but evaporated the next day, except when the air was moist and damp; it then remained the entire day. It contained a large percentage of gum; in the experiments conducted in sugar coal dust, without the addition of any inorganic ingredients other than 0.004 grm. of nitrate of ammonia, the globule was remarkably abundant in gum. This globule made its appearance on the end of the first leaf in *every experiment.*

After the evaporation of the drop, a gummy substance as residuum may be seen at the extremity of the leaf during the day-time. That this phenomenon is independent of the soil in which the plant is grown, is certainly evident from the fact

Digitized by Google

that it was observed on the plants grown in sand, as well as those grown in brook sand, in quartz, and in the sugar coal dust. The fruit which was obtained from an experiment made in sand with nitrate of ammonia, without any other inorganic substances, was planted in the same ingredients, and the first leaf again produced the globule, which remained longer during the day-time than the others. The entire phenomenon is sometimes completed in two days.

22. A singular phenomenon occurred during an experiment to test the germinative properties of fruits grown in hydrate of alumina; there was an abnormal development of the first leaf, as it came forth from its sheath; it retained, although fully an inch long, its tubular or cylindrical form without spreading at the end. This abnormality is indicative of a disturbance in the development of the roots, which did not occur in testing the vegetative properties of the five fruits grown in the Almerode clay.

23. There were 0.02 grm. of nitrate of ammonia diluted in 15 grms. of distilled water, and added to a plant which had developed its first and second leaves in pulverized quartz, to which were added the usual inorganic ingredients. The result was the destruction of the plant, after becoming covered with yellow spots. Whatever inorganic elements it is intended to furnish the plant from ammonia, must be introduced into the soil before germination commences, or else dilute it in the proportion of .01 grm. of nitrate of ammonia to 50 grms. of distilled water; apply in sprinkling the compound, answering the place of soil, otherwise the organism, particularly in the development of the roots, becomes disturbed.

24. Since the plant itself is the best analyst of the soil, and by its development testifies to the condition of the soil much more correctly than any artificial analysis by chemists possibly can determine, it certainly is desirable that practical agriculturists adopt some method similar to this series of experiments, that is, take a number of water-tight vessels, fill them with

Digitized by Google

soil from the same spot, then add a different inorganic ingredient to each vessel, plant seed therein and note the differences, and observe the effect of the ingredient added.

25. Experiments in silica, prepared from silicate of potassium, thoroughly washed and heated to a white heat, has failed to produce a plant. Even with the addition of all the inorganic substances usually employed, it produced a very weak and dwarfish plant only. It appears that the fine laminæ of the silica are entirely too light, the roots elevating them in every direction, while the roots themselves appear to be little else than elongated air bladders, which soon collapse and the plant dies.

26. More recent experiments indicate that sodium is of essential importance in the formation of fruit in the oat plant.

27. With regard to iron, it is necessary to remark that in the ashes of a plant grown in a basis containing phosphate of iron, there was no great difficulty in tracing iron in combination with sulphuric acid in the ashes of the plant; but chemical analysis would never have indicated the essential part performed by iron in the formation and development of fruit, if the synthetic system had not been adopted.

Experiments with Spring Barley.

The experiments with this plant were conducted solely to determine the requisite inorganic ingredients to produce and develop fruit. They were conducted in waxen vessels, and in all other respects conducted as were the experiments with the oat plant. The composition of the artificial soil is here repeated, so that the reader can see how it compares with the preceding ones:

65.000 grms. well heated brook sand, fully oxydized, but not washed.
0.1 grm. carbonate of lime.
0.04 " tri-phosphate of lime.
0.03 " sulphate of lime.
0.02 " carbonate of magnesia.

Digitized by Google

0.02 grm. nitrate of potassium
0.018 " silicic acid } dissolved
0.009 " potassium } In 15 grms. of distilled water.

The development of the plant was normal. The stalk was nineteen inches long, produced eight blossoms, each one of which produced a perfect fruit, which possessed all the requisite germinative properties. This experiment served as a test.

The composition of an artificial soil, in which sodium is entirely omitted, is here presented:

65.000 grms. coarsely pulverized mountain crystal, (or quartz) carefully washed.
0.50 grm. carbonate of lime.
0.06 " tri-phosphate of lime.
0.03 " sulphate of lime.
0.05 " basic phosphate of iron, heated with mountain crystal.
0.02 " nitrate of potassium dissolved in 15 grms. distilled water.
0.001 " carbonate of magnesia.

The seed planted in this composition was obtained from a barley plant which was grown entirely without sodium, but most certainly in cleansed brook sand. The stalk was twelve inches long. The ear or spike, remained sheathed in the upper leaf, was undeveloped; bore neither blossom nor fruit. It must be remarked, however, that in the experiment which produced the seed employed in the above experiment, chloride of sodium was so intimately combined with the brook sand, as not to be entirely inseparable, even after the most thorough treatment. It would then appear that the chloride of sodium in the preceding experiment served the purpose of forming and developing the fruit. Two more experiments with this plant appear to be worthy of notice:

First.—Without sodium. The same composition with mountain crystal as in the preceding experiment. Stalk nine inches long, the ear or spike not visible, without flowers and

Digitized by Google

without fruit. Although it was regularly watered, the plant gradually died. No side shoots.

Second.—With sodium. The same inorganic composition as in the last experiment, with the addition of four miligrams of nitrate of sodium. Stalk sixteen inches long, normal, the entire ear visible, with long beards but without pollen sacs, without blossoms, and consequently fruitless.

Results.

From the fourteen experiments which were made with barley, it appears that another ingredient aside from sodium, is necessary for fruit formation and development, which the plant found in brook sand, because in this latter it bore fruit —the essential ingredient was a chloride. Later experiments prove most incontestably that iron is absolutely necessary in the structure of the stalk.

Experiments with Winter Wheat.

In well-heated brook sand, but not washed, digested or triturated, but with the addition of the usual inorganic ingredients, together with nitrate of potassium, fruit was produced.

In carefully washed brook sand, which was afterward digested in boiling dilute sulphuric acid, to which the usual ingredients were added, but sodium and chlorine omitted, the stalk was weak and decrepid, and produced neither flowers nor fruit.

In the same artificial soil, with sodium added, the stalk attained the length of twenty-one inches, produced thirty-four leaves, bore three flowers and two perfect fruits.

No globule or dew-drop was found on the wheat plant, as was on the oats and barley, in the experiments with them. The experiments with the wheat plant indicate the necessity of sodium for the formation and development of fruit. Eighteen experiments were made in the wheat plant, all, however, in brook sand, digested in sulphuric acid; the most important of these experiments are the following:

Digitized by Google

EXPERIMENT FIRST—WITHOUT SODA AND WITHOUT CHLORINE.

65.000 grms. crystallized quartz—the finest powder removed by washing.*

0.02 grms. nitrate of potassium dissolved in fifteen grms. of distilled water.

0.1 nitro-carbonate of lime.

0.05 " tri-phosphate of lime.

0.02 " sulphate of lime.

0.02 " carbonate of magnesia.

0.04 " basic phosphate of oxide of iron heated with the quartz.

0.001 nitro-carbonate of the oxide of manganese.

The plant died while in the sixth leaf, without any stem or flowers, thus showing the necessity of sodium.

For the sake of brevity in the following experiments, the annexed names of six salts will be designated by that of "the usual salts," viz.:

Nitrate of potash, carbonate of lime, phosphate of lime, sulphate of lime, carbonate of magnesia, carbonate of manganese.

EXPERIMENT SECOND—WITH NITRATE OF SODIUM.

One milligram of nitrate of sodium dissolved in fifteen grms. of distilled water "the usual salts," added when the plant was in the third leaf. The plant died, in the seventh leaf without stem. The last three leaves had the appearance of bristles rather than any thing else. The roots were exceedingly delicate.

3d Experiment, with five milligrams of nitrate of sodium, together with "the usual salts." The plant died without

* The finest powder of the pulverized quartz was necessarily removed, in order to remove as far as possible all the chloride of potash and chloride of soda, which is inherent in the crystallized quartz. These chlorides have invariably been found in German, French and American crystals.

Digitized by Google

forming any stem, and the last leaves were again like bristles. The cause in this case may be attributed to the fact that the plant germinated in a compound destitute of sodium.

4th Experiment, with same substances and the "usual salts," with the addition of one milligram of chloride of sodium. Plant died without forming stalk—it had germinated in a compound destitute of sodium.

The last three experiments do not indicate the necessity of the presence or absence of sodium, probably because they were made in an inverted manner; yet these experiments possess a scientific interest, as they seem to demonstrate the influence which the sodium exerts upon the activity of the component parts of the germinating seed.

5th Experiment, without nitrate of sodium, with chloride of sodium. The chloride of sodium was in this case added before germination took place, and from this cause, it is presumed, that the stalk attained the hight of fourteen inches. It bore no perfect blossom, the flowering portion of the defective ear consists of two bearded chaff-like scales. The plant had fifteen leaves, was abnormal, but important. The "usual salts" were, of course, added.

6th Experiment, omitting iron, but substituting five milligrams of nitrate of sodium and one milligram of chloride of sodium, together with the "usual salts." The stalk was without an ear, delicate, sent out two suckers in the early part of its existence, but which produced no stalks. The compound was completed before the seeds were put in to germinate. The absence of iron is here readily discernible.

7th Experiment, omitting iron and manganese. Five milligrams of nitrate of sodium, and one milligram of chloride of sodium were in the compound, together with the "usual salts." The plant remained without stalk and without bloom. The leaves were of a lively green. The necessity of manganese for the growth of the stalk in this case, seems very manifest. The elongation of the first sprout consumed an extraordinary amount of time.

Digitized by Google

8th Experiment, omitting iron, manganese, sodium, chlorine, but with the "usual salts." The plant produced seven green leaves, but produced neither stalk nor bloom.

9th Experiment, with the addition of iron, manganese and the "usual salts," together with three milligrams of nitrate of sodium and one-half milligram of chloride of sodium. This plant exhibited extraordinary tardiness during the stalk formative period; it remained absolutely in *statu quo* during six weeks, when there was added one-fifth of a milligram of sulphate of iron dissolved in fourteen grms. of water. In a remarkably short period of time the stalk "shot up" to the hight of nine inches; but the plant died of defective watering. It was, however, manifest that no flowers were to be formed.

Results.

From the contradictory results in the foregoing experiments, it is very manifest that another ingredient is essential to this artificial soil in order to produce flowers; and the disparity in these results can be fully understood and investigated when the undetermined ingredient shall have been discovered. Oxide of iron, oxide of manganese and chloride of lime appear to be essential, but yet not sufficient to produce the flowers.

Experiment with Spring Wheat.

The quartz in this experiment was digested in muriatic acid, because it appeared to be of a slightly ferruginous nature;—it was afterward washed very carefully and dried. Omitting iron and chlorine.

65.000 grms. quartz,

0.035 Silicic acid } liquified by heat,
0.018 Potassium }

0.02 Nitrate of potash,
0.005 Nitrate of sodium,
0.002 Nitrate of ammonia,
0.1 Carbonate of lime,
0.05 Tri phosphate of lime,
0.08 Sulphate of lime,
0.02 Carbonate of magnesia.

} dissolved in 15 grs. distilled water.

Digitized by Google

The plant was normal and green, thirteen inches long, bore five flowers without anthers, and consequently without fruit. Notwithstanding the severe trituration and digestion of the quartz in muriatic acid it yet contained inclosed within its small particles, glimmerings of iron, hence this experiment is important as serving to show that very little iron is sufficient to produce the desired result.

Experiment with Winter Rye.

This plant conducted itself strangely, according as it was placed to enjoy the morning or noon-day sun only.

There were several experiments made with fine brook sand, the other ingredients being the same. Two of the experiment vessels were so situated at a window as to enjoy the morning sun only; while two others were placed at another window so as to enjoy the noon-day sun only. These plants all bloomed; those which enjoyed the noon-day sun produced fruit while those placed at the east window produced none. These experiments I have repeated several times, and always with the same results. The cause is not very manifest for this singular phenomenon, if it is not to be found in the fact of polarization of light by the glass in the window, and the additional fact that the chemical or actinic rays prevail to a much greater extent at noon than in the morning.

In all these experiments with winter rye as well as with the winter wheat, no drop was apparent at the extreme point of the young leaflet, as there was in the oats and barley.

The ingredients were nitrate of potassium, carbonate of lime, phosphate of lime, sulphate of lime, carbonate of magnesia, basic phosphate of oxide of iron, carbonate of manganese. This composition contained no sodium. In all the other experiments with mountain crystal, with the addition of nitrate of sodium, chloride of sodium, phosphate of oxide of iron, as well as when the oxide of iron and nitrate of sodium were omitted, and also when nitrate of sodium and chloride of sodium were mingled, I obtained no flowers at all.

Digitized by Google

EXPERIMENTS WITH A VIEW OF ASCERTAINING WHAT INORGANIC INGREDIENTS ARE NECESSARY TO BE ADDED TO THE BARREN VIRGIN SOIL OF WESTPHALIA TO MAKE IT FERTILE.

The virgin sandy soil for experiment was obtained from immediately beneath the depth attained from the surface by the forest weeds. The quantity necessary for experiment, was carefully dried and then thoroughly mixed, then sixty-five grammes were placed in each of the wax-coated vessels for experiment, after having been thoroughly mixed with ingredients to be added. The plant selected for experiment was the white oat.

A single grain was all that was retained in each experiment; that one which germinated the best was the one used; distilled water was the kind used. 1st. Without any of the artificial compounds it produced a very weak and delicate plant. 2nd. When 0.01 grm. of carbonate of ammonia was added, it produced a plant which died in the second leaf. 3d. When 0.05 grm. of phosphate lime was added to the ammonia named in the preceding experiment, a very tender and sickly plant was produced, in which one leaf died as fast as another was produced. 4th. When 0.02 grm. of nitrate of potassium was substituted for the carbonate of ammonia, but the other ingredients the same as the preceding experiments, an exceedingly weak plant was produced, the fourth leaf of which became yellow spotted. 5th. With 0.01 grm. of nitrate of potassium only, the plant attained the length of three inches, but was very feeble. 6th. With 0.02 grm. nitrate of potash and 0.03 grm. sulphate of lime, the plant produced was very weak. 7th. With 0.05 grm. superphosphate of lime, 0.03 grm. of sulphate of lime and 0.02 grm. nitrate of potash a very vigorous plant was produced, with broad dark green leaves and strong stalk. 8th. With 0.1 grm. of carbonate of lime, 0.05 superphosphate of lime, 0.01 sulphate of lime and 0.02 nitrate of potash, the plant was very vigorous. 9th. With 0.05 grm. superphosphate of lime, 0.03 sulphate of lime, 0.02 carbonate

Digitized by Google

magnesia and 0.02 of nitrate of potash, a very vigorous plant was produced. The result of these experiments indicate that not only is phosphate of lime wanting to make this barren soil fertile, but that sulphate of lime and potash are equally essential.

These experiments are very interesting, inasmuch as they prove most conclusively that superphosphate or phosphoric acid is not the *only* ingredient necessary to fertilize the soil.

After all, the plant itself is the best chemist to analyze the soil, and for the practical agriculturist (with his present knowledge on the subject) is certainly the most unerring.

It may not be inappropriate in this connection to insert the following, referred to by Liebig in his Agricultural Chemistry:

EXPERIMENTS OF WEIGMANN AND POLSTORF.

The composition of the artificial soil used in the experiments of Wiegmann and Polstorf, on the organic ingredients of plants, was as follows (Preischrift. p. 9):—

Quartzy sand	861.26
Sulphate of potash	0.34
Chloride of sodium	0.13
Gypsum (anhydrous)	1.25
Chalk (elutriated)	10.00
Carbonate of magnesia	5.00
Peroxide of manganese	2.50
Peroxide of iron	10.00
Hydrated alumina	15.00
Phosphate of lime	15.60
Acid of peat, with potash*	3.41
" " soda	2.22
" " ammonia	10.29
" " lime	8.07
" " magnesia	1.97
" " peroxide of iron	3.22
" " alumina	4.64
Insoluble acid of peat	50.00

* This salt was made by boiling common peat with weak potash ley, and precipitating, by means of sulphuric acid, the dark colored solution.

Digitized by Google

The following experiments were instituted in pure sand, and in the artificial soil:

Vicia Sativa.

A.—*In Pure Sand.*—The vetches attained by the 4th of July a hight of ten inches, and seemed disposed to put out blossoms. On the 6th of the same month, the blossoms unfolded; and on the 11th they formed small pods, which, however, did not contain seeds, and withered away by the 15th. Similar plants, which had already begun to have yellow leaves below, were drawn with their roots out of the sand, the roots washed with distilled water, and then dried and incinerated.

B.—*In Artificial Soil.*—The plants reached the hight of eighteen inches by the middle of June, so that it became necessary to support them with sticks; they blossomed luxuriantly on the 16th of June; and about the 26th put out many healthy pods, which contained, on the 8th of August, ripe seeds, capable of germinating. Similar plants to the above were taken with the roots from the soil; they were then washed and incinerated.

Hordeum Vulgare.

A.—*In Pure Sand.*—The barley reached on the 25th of June, when it blossomed imperfectly, a hight of 1¼ foot, but it did not produce seed; and, in the month of July, the points of the leaves became yellow; on which account, on the 1st of

---

This precipitate is that termed Torfsaeure (acid of peat), in the above analysis. The salts of this acid, referred to in the analysis, were obtained by dissolving this acid in potash, soda, or ammonia, and by evaporating the solutions; the salts of magnesia, lime, peroxide of iron, and alumina, were obtained by saturating this solution with their respective bases, by which means double decomposition was effected. Humus is the substance remaining by the decay of animal and of vegetable matters, which are seldom absent from a soil. This was replaced by the acid of peat in the experiments of Wiegmann and Polstorf. When the acid of peat is boiled for some time with water, it passes into an insoluble modification, denoted above as insoluble acid of peat.

Digitized by Google

August, we removed the plants from the soil, and treated them as before.

B.—*In Artificial Soil.*—The barley, by the 25th of June, had reached a hight of 2½ feet, by which time it had blossomed perfectly; and yielded, on the 10th of August, ripe and perfect seeds; upon which the plants, together with their roots, were taken from the soil, and treated as formerly.

Avena Sativa.

A.—*In Pure Sand.*—The oats, on the 30th of June, were 1½ feet in hight, but had blossomed very imperfectly; they did not produce fruit; and, in the course of July, the points of their leaves became yellow, as in the case of the barley; on which account the stalks were removed from the soil on the 1st of August, and treated as formerly.

B.—*In Artificial Soil.*—The oats reached 2½ feet on the 28th of June, having blossomed perfectly. By the 16th of August they had produced ripe and perfect seeds; the stalks and roots were, therefore, removed from the soil, and treated as above.

Polygonum Fagopyrum.

A.—*In Pure Sand.*—The buckwheat, on the 8th of May, seemed to flourish the best of all the plants grown on pure sand. By the end of June, it had reached a hight of 1½ feet, and branched out considerably. On the 28th of June, it began to blossom, and continued to blossom till September, without producing seeds. It would certainly have continued to blossom still longer, had we not removed it from the soil on the 4th of September, as it lost too many leaves; it was treated as before.

B.—*In Artificial Soil.*—The buckwheat grew very quickly in this soil, and reached a hight of 2½ feet. It branched out so strongly that it was necessary to support it with a stick; it began to blossom on the 15th of June, and produced perfect seeds, the greater number of which were ripe on the 12th of

Digitized by Google

August. On the 4th of September, it was taken from the soil along with the roots, and treated as before, on account of losing too many leaves from below; although it was partly still in blossom, and with unripe fruit.

Nicotiana Tabacum.

A.—*In Pure Sand.*—The tobacco plant sown on the 10th of May did not appear till the 2d of June, although it then grew in the normal manner; when the plants had obtained their second pair of leaves I removed the superfluous plants, leaving only the five strongest specimens. These continued to grow very slowly till the occurrence of frost in October, and obtained only a hight of five inches, without forming a stem. They were removed along with their roots from the sand on the 21st of October, and treated as the above.

B.—*In Artificial Soil.*—The tobacco sown on the 10th of May came up on the 22d of the same month, and grew luxuriantly. When the plants obtained the second pair of leaves, I withdrew the superfluous plants, and allowed only the three strongest to remain. These obtained stems of above three feet in hight, with many leaves; on the 25th of July they began to blossom; on the 10th of August they put forth seeds; and, on the 8th of September, ripe seed capsules, with completely ripe seeds, were obtained. On the 27th of October, the plants were removed from the soil, and treated as above.

Trifolium Pratense.

A.—*In Pure Sand.*—The clover, which appeared on the 5th of May, grew at first pretty luxuriantly, but reached a hight of only 3 1-2 inches by the 15th of October, when its leaves became suddenly brown, in consequence of which I removed it from the soil, and treated it as above.

B.—*In Artificial Soil.*—The clover reached a hight of ten inches by the 15th of October; it was bushy, and its color was dark green. It was taken from the soil, in order to com-

Digitized by Google

pare it with the former experiments, and was treated in the same way.

Constituents of the Ashes of the Seed.

100 parts of dry seeds yield—

	Soluble in water.	Soluble in muriatic acid.	Silica.	Ashes in 100 parts.
Vicia sativa.....	1.562	0.568	0.442	= 2.567
Hordeum Vulgare.....	0.746	0.568	1.128	= 2.432
Avena sativa.....	0.465	0.277	2.122	= 2.864
Polygonum fagopyrum....	0.823	8.547	0.152	= 1.522
Trifolium pratense.....	1.218	3.187	0.282	= 4.687

Constituents of the Ashes of the Plants grown in Pure Sand and in the Artificial Soil.

		Soluble in water.	Soluble in muriatic acid.	Insoluble in water and muriatic acid. (Silica.)	Ashes.
Vicia sativa, 15 grms. plants dried in air.	In sand.....	0.516	0.375	0.135	= 1.026
	In artificial soil.	0.693	0.821	0.320	= 1.834
Hordeum vulgare, 12.5 grms. plants.	Sand.....	0.123	0.195	0.355	= 0.673
	Soil	0.167	0.226	0.487	= 0.880
Avena sativa, 13 grms. plants.....	Sand	0.216	0.024	0.354	= 0.594
	Soil	0.225	0.030	0.461	= 0.746
Polygonum fagopyrum	Sand (12 gr. plants.....	0.086	0.094	0.045	= 0.225
	Soil (12.7 gr. plants.....	0.148	0.226	0.133	= 0.507
Nicotiana tabacum ...	Sand (4 grms plants.....	0.223	0.252	0.031	= 0.506
	Soil (12.5 plants.....	1.146	2.228	0.594	= 3.928
Trifolium pratense, 14.5 grms. plants.	Sand.....	0.522	0.350	0.091	= 0.963
	Soil	0.659	0.943	0.082	= 1.684

The preceding numbers express the unequal weight of mineral nutritive substances taken up from the sand and artificial soil by equal weights of the different plants mentioned. The absolute and not the relative weight of the component parts of the ashes is given. For example, the five tobacco plants grown in sand gave 0.506 gr. in ashes, while the three which grew in the artificial soil gave 3.923; five would, therefore,

Digitized by Google

have given 6.525 gr. The proportion of the mineral ingredients taken up by five tobacco plants from the sand, and that taken up from the artificial soil by an equal number of plants, is as 10 : 120. In an equal space of time, those which grew in the artificial soil absorbed nearly thirteen times more of inorganic ingredients than those in the sand, and the whole development of the plant was exactly in proportion to the supply of food. Wiegmann and Polstorf subtracted the ashes of the seed used from the numbers in the last line, which show the amount of ashes in a given weight of the grown plant; but this has caused a small error in the numbers, as all the plants grown in the sand were reduced to ashes, and a corresponding amount only of those grown in the artificial soil. The weight of the seed of every plant grown was three grammes, if we except the tobacco, which was not weighed.

Table showing the Amount of Moisture in the Vegetable Substances analyzed in the Experiments of Boussingault.

	Subst. dried at 110° C.	Water.		Subst. dried at 110° C.	Water.
Wheat	0.855	0.145	Beet	0.122	0.878
Rye	0.834	0.166	Turnips	0.075	0.925
Oats	0.792	0.208	Helianthus tub...	0.208	0.792
Wheat straw	0.740	0.260	Peas	0.914	0.086
Rye straw	0.813	0.187	Pea straw	0.822	0.118
Oat Straw	0.713	0.287	Clover stalk	0.790	0.210
Potatoes	0.241	0.759	Stalk of Hel. tub.	0.871	0.129

The foregoing are practical demonstrations of the part played by each inorganic substance, and the proof is conclusive that without inorganic substances and certain other conditions, such as temperature, atmosphere, light, etc., plants can not attain to perfection.

Digitized by Google

CHAPTER X.

EXPERIMENTS OF GILBERT AND LAWES.

UNFORTUNATELY for the immediate interests of agriculture, there are two parties, each claiming that the opponent is laboring under erroneous impressions. The one party is Liebigian, or followers of Liebig, who believe that mineral manures are a *sine qua non* to successful agriculture, while the opponents (who are chiefly to be found marshaling under the banner of Messrs. Gilbert and Lawes, of England) are advocates of organic manures. The experiments of Salm Horstmarr, and those referred to by Liebig, are not introduced with a view of interfering with the discussion or investigation of the parties, but as a record of a series of experiments, which, in the opinion of the writer, have been made in the right direction, and in the same spirit and with the same intent, the following extract from experiments, by Messrs. Gilbert & Lawes, is introduced:*

The composition of the grain yielding the most important article of human food in temperate climates, its yield of valuable products, and the varying composition either of the grain itself, or of these products, according to the conditions of growth, or the circumstances of after preparation, are subjects worthy the attention equally of states and of men of science. Accordingly we find, that a chemical examination of wheat grain and its products, has from time to time been undertaken by chemists of repute; sometimes as a matter of private investigation, and at others of public inquiry; and

* On some points in the composition of wheat grain, its products in the mill and bread. London, 1857. 57pp. 8 vo.

Digitized by Google

almost as numerous as the names of experimenters, are the special lines of research which they have selected.

We are indebted to Beccaria for the first notice, more than a century ago, of the gluten in wheat. Among the earlier investigators of the subsequent period, are Proust, Vauquelin, De Saussure and Vogel, who have examined the proximate principles, and some of the changes to which they are subject, in various descriptions of wheat, of flour, or of bread. M. Boussingault has somewhat elaborately studied various branches of the subject more recently; and we are indebted to Dumas, Payen, Johnson, and Dr. R. D. Thomson, for original as well as a considerable amount of collected information. The most recent, on some points, the most detailed, and from advance in methods, perhaps on some also the most reliable, are the results of M. Peligot, in 1849, on the proximate constitution of various kinds of wheat, and of M. Millon, in 1849 and 1854, on somewhat similar points. Lastly, in 1853, M. Poggiale, and in 1855, Dr. Maclagan, have given the results of their investigations on the characters and composition of bread.

Besides these more general investigations, we have had in recent times many special inquiries connected with our subject. Thus, M. Boussingault has given us an analysis of the ashes of wheat; and many other such analyses have been made in Germany, and elsewhere, since the first appearance in 1840, of Baron Liebig's work on "Chemistry in its Applications to Agriculture and Physiology." In this country, Mr. Way has given us the most extensive series of wheat-grain-ash analyses, his list including those of twenty-six specimens.

The plan of our own investigation, which unfortunately has been much less perfectly filled up than we at first intended, was entered upon more than a dozen years ago, and was devised with reference to the following points:

1st. The influence of varying characters of season, and of various manuring, upon the organic and mineral composition of wheat grain.

Digitized by Google

2d. The characters of varieties, especially in relation to their adaptation, and the qualities, they then develop, under the influence of broader distinctions as to locality, altitude, latitude and varying climatic circumstances generally.

It is in the second branch of the inquiry that we have fallen the furthest short of our intentions. With a view to its prosecution, a journey through the chief corn growing districts of Europe, commencing at the northernmost point at which wheat is grown successfully, was about to be undertaken in 1848; but the social disturbances on the continent at that period, necessarily prevented it. The plan proposed was—to collect information, as to the geological and meteorological characters of the various localities, as to the mode of culture, and as to the general average yield, both in straw and grain; and lastly, to procure characteristic specimens for chemical examination at home. Failing entirely in the execution of this design, the exhibition of 1851 was looked forward to as an opportunity for procuring specimens not only of wheat, but of other vegetable products, and perhaps also important particulars of their growth, from various countries and climates. Such, however, was the division of authority, and such the alleged preference given to public institutions in such matters, that, whether the latter benefited or not, the collection which we, as private individuals, were enabled to make, was entirely inadequate to our object. From these difficulties it is, that our second main object of inquiry was necessarily to a great extent abandoned. Chiefly for this reason, but partly owing to the pressure of other subjects, the first or more limited or local branch of the investigation has in recent years been but imperfectly followed up. And, as it is probable that it must for some time remain so, it has been thought desirable to put on record the results already obtained; hoping that they may serve the double purpose, of confirming or adding to previously existing knowledge, and of indicating to others the points most requiring further study.

Digitized by Google

The following is a brief outline of the plan of investigation which has yielded the results which we have now to lay before the society:

From the same season 1843–4, up to the present time, wheat has been growing in the field continuously, both without manure, by ordinary, and by various chemical manures. As a general rule, the same description of manure has succeeded year after year on the same plot of land. The amount of produce, corn, straw and chaff, and its characters as to weight per bushel, etc., have in every case, been carefully ascertained and recorded. Samples from each plot—both grain and straw—have also been collected every year. Of each of these samples, two weighed portions are coarsely ground; the *dry matter* determined at a temperature of 212°; and the *ash* by burning on sheets of platinum, in cast iron muffles arranged for that purpose.* Other weighed portions of grain and straw are partially dried, so as to prevent their decomposition; and in this state they are preserved for any examination of their organic constituents. By this course of procedure, a vast mass of results has been obtained, illustrating the influence of season and manuring, upon the percentage of dry substance, and of mineral constituents, in the produce. In selected cases, the *nitrogen* in the grain, and in the straw, has been determined. A summary table of these dry matter, ash, and nitrogen results, will be given below. In from twenty to thirty cases complete analyses of the grain ashes have been made, and the results of these will be given in full.

Besides the experiments above described, in selected cases, chiefly from the produce of the earlier years of the field experiments, it was sought to ascertain the comparative *yield of flour*, and also the characters of the flour, of grain grown by different manures in the same season, or by the produce of different seasons. The *colonist's steel handmill* was first had

* The dry matter and ash, were not determined in such complete series in the earlier years, as in the later.

Digitized by Google

recourse to for this purpose. But it was soon found that it was extremely difficult so to regulate the machine, as to secure uniform action upon the different grains; and it was further found, that the grain, and especially the bran, was cut up rather than crushed, so as to leave too much of flour in the portion separated as bran, and too much of bran in that separated as flour; and hence the results were not sufficiently comparable with those of the ordinary mill. Arrangements were therefore made for prosecuting the inquiry at a flour mill in the neighborhood, worked by water power. Weighed quantities of the selected samples (from 125 to 250 lbs. each) were passed through the stones, and the "*meal*" thus obtained through the dressing machine, under our own personal superintendence; great care being taken to clear from the different parts of the apparatus the whole of one lot, before another was commenced upon.

The yield in the dressing machine of each of the different products was ascertained, and its percentage in relation to the total grain or its "meal," has been calculated. Portions of each of these products have had their dry matter (at 212°) and their mineral matter (by burning on platinum) determined. The percentage of nitrogen in a few selected series—from the finest flour down to the coarsest bran—has also been estimated; and in the same cases, the amounts of one or two of the more important constituents of the ash have also been determined. The results of these dry matter, ash, nitrogen, and constituent of ash determinations, in the series of different products obtained in the mill, will be given in tables further on.

The original design was to complete the examination of the mill products, by determining, in several series of them, the percentage of each of their proximate organic principles; and also the amount and composition of mineral matters, associated with them respectively. It was hoped, by this latter inquiry, to obtain important collateral information, bearing upon the influence of various constituents upon the healthy

Digitized by Google

and special development of the plant. Although, however, specimens of the flour are preserved for this purpose, as well as the ashes of each crude product, it is feared that this subject can not be proceeded with, at least for a considerable time to come.

Portions of the different products of the dressing machine (including more or less of the finest flour, of the more granular, or of the more branny particles respectively), from grains of somewhat various history of growth, having been experimented upon to ascertain their comparative bread-making qualities; and these results, together with a few examinations of baker's bread, and a discussion of the results of other experimenters, as to the yield of bread from a given amount of flour, and the percentage of water and of nitrogen in the former, will be given below.

With this short outline of the plan of investigation which has been pursued, we proceed now to a discussion of the results which have been obtained.

In Table I. are given, in the first four columns, certain prominent characters of the produce of each of ten years of the successive growth of wheat as above described. The items are:

The total produce per acre (corn and straw), in lbs.;
The per cent. of corn in the total produce:
The per cent. of dressed corn in the total; and,
The weight per bushel of dressed corn in lbs.

The figure given for each year, generally represents the average of about forty cases; and the characters enumerated are the best which can be given in a summary and numerical form, to indicate the more or less favorable condition of the respective seasons for the healthy development of the crop, and the perfect maturation of the grain.

In the second set of three columns are given, side by side with the general characters just described, the percentages in the grain of each year:

Digitized by Google

Of dry substance;
Of ash in dry substance;
Of nitrogen in dry substance;

the two former items being in most cases the average of 30 to 40 cases in each year; but the per cent. of *nitrogen* is, in each instance, the mean of a few selected cases only.

In the third set of three columns, are given similar particulars relating to the composition of the straw. The percentages of dry substance and of ash in the straw, are, however, not the averages of so many cases in each year, as are those for the corn; and the determinations of nitrogen in the straw, have also been made in fewer cases than in the grain.

TABLE I.

GENERAL SUMMARY.

Harvests.	Particulars of the Produce.				Composition of Grain.			Composition of Straw.		
	Total corn and straw per acre in lbs.	Per cent. corn in total produce.....	Per cent. dressed corn in total corn.....	Weight per bushel of dressed corn in lbs.	Per cent. dry (212°).	Per cent. ash in dry.	Per cent. nitrogen in dry.....	Per cent. dry (212°).	Per cent. ash in dry.	Per cent. nitrogen in dry.....
1845	5545	33.1	90.1	56.7	80.8	1.91	2.25	.....	7.06	0.92
1846	4114	43.1	93.2	63.1	84.3	1.96	2.15	.....	6.02	0.67
1847	5221	36.4	93.6	62.0	.....	... ..	2.30	.....	5.56	0.73
1848	4517	36.7	89.0	58.5	80.3	2.02	2.39	.....	7.24	0.78
1849	5321	40.9	95.5	63.5	83.1	1.84	1.94	82.6	6.17	0.82
1850	5496	33.6	94.3	60.9	84.4	1.99	2.15	84.4	5.88	0.87
1851	5279	38.2	92.1	62.6	84.2	1.89	1.98	84.7	5.88	0.78
1852	4299	31.6	92.1	56.7	83.2	2.00	2.38	82.6	6.53	0.79
1853	3932	25.1	85.9	50.2	80.8	2.24	2.35	81.0	6.27	1.20
1854	6803	35.8	95.6	61.4	84.9	1.93	2.14	83.7	5.08	0.69
Means.	5053	35.4	92.1	59.6	82.9	1.98	2.20	83.2	6.17	0.82

Digitized by Google

It will thus be seen that the preceding table affords a summary view of a really enormous amount of experimental result, and we ought to be able by its means to discover, at least the broad and characteristic effects of varying seasons, upon the composition of the crop.* This, indeed, is all we could hope to attain, in such a mere outline and general treatment of the subject as is appropriate to our present purpose.

Leaving then out of view all minor points, and confining ourselves to our already defined object—namely, that of ascertaining the general direction of the influence of variation of season upon the composition of the wheat crop—we can not fail to see, that wherever the three items indicating the *quality* of the produce markedly distinguish the crop as favorably developed, we have a general tendency to a high percentage of dry substance, and to a low percentage both of mineral matter, and of nitrogen in that dry substance. This generalization is more especially applicable to the grain; but with some exceptions, mostly explicable on a detailed consideration of the circumstances and degree of its development, it applies to a great extent to the straw also.

Let us take in illustration the extreme cases in the table. The seasons of 1846, 1849, and 1851, with, in the cases of the two latter, large produce also, give us the best proportion of corn in total produce, more than the average proportion of dressed corn in total corn, and the highest weight per bushel, a very significant character. With this cumulative evidence as to the relatively favorable development and maturation of these crops, we find the grain in two of the cases, to be among the highest in percentage of dry matter; and in the third (1849) though not so high as we should have expected, it is

* It should be stated, that up to 1848 inclusive, the description of wheat was the Old Red Lammas; from 1849 to 1852 inclusive, it was the Red Cluster, and since that time the Rostock. The variations, according to season, both in the character and composition of the produce, are, however, very marked within the period of growth of each separate description.

Digitized by Google

still above the average. The percentages of mineral matter and of nitrogen in the dry substances of the grain are at the same time in these three cases, the lowest in the series. The seasons of 1850 and 1854 again, with large amounts of produce, yielded also very fairly developed grain; and coincidently they afford a high percentage of dry substance, and lower percentages both of mineral matter, and of nitrogen, in that dry substance, than the cases of obviously inferior maturation. With some exceptions, it will be seen, that the straws also of these five better years, give a tendency to low percentages both of mineral matter and of nitrogen in their dry substance.

Turning now to the converse aspect, the season of 1853, shows itself in the general characters of the produce, to have been in every respect the least favorable to the crop; and it should be added that in this instance (as well as in 1845, to which we shall next refer) the seed was not sown until the spring. In 1853 the produce of grain was small, as well as very bad in quality; and with these characters, we have in the grain nearly the lowest percentage of dry matter and the highest percentage of ash and of nitrogen in that dry matter. In the straw, too, the dry matter is low, the ash somewhat high, the nitrogen much the highest in the series. In 1845, another year of spring-sowing, and at the same time of very bad quality of produce, we have nevertheless a large *amount* of growth; a fact which tends to explain some of the differences in composition as compared with 1853. Thus, 1845 gives us low percentage of dry matter, but not very high, either ash or nitrogen, in the grain. The straw, however, gives high percents both of ash and of nitrogen; it being in the latter point next in order to 1853. The seasons of 1848 and 1852 again show low characters of produce. The former has coincidently the lowest percentage of dry matter in the grain in the series; and both have high percentage of ash and nitrogen in the dry substance of the grain. In the straw, the ash is in 1848 the highest, and in 1852 above the average; the

Digitized by Google

nitrogen in dry matter of straw being however in neither instance high.

In several of the cases there cited, there are deviations from our general assumption on one point or other. But an examination in greater detail, would in most or all of them clear up the apparent discrepancy. When indeed, we bear in mind how infinitely varied was the mutual adaptation of climatic circumstances to stage of growth of the plant, in almost every case, it would indeed be anomalous, did we not find a corresponding variation on some point or other, in the characters or composition of the crop. Still, we have the fact broadly marked, that within the range of our own locality and climate, high maturation of the wheat crop is, other things being equal, generally associated with a high percentage of dry substance, and a low percentage of both mineral and nitrogenous constituents. Were we, however, extending the period of our review, and going into detail as to varying climatic circumstances, interesting exceptions could be pointed out.

It may be observed in passing, that owing to the general relationships of the amounts of corn to straw, and the generally coincident variations in the percentages of nitrogen in each, the tendency of all these variations is in a degree so to neutralize each other, as to give a comparatively limited range of difference in the figures, representing for each year, the percentage of nitrogen in the dry substance of the total produce—corn and straw together.

The tendency of maturation, to reduce the percentages of mineral matter, and frequently of nitrogen also, is not observable in corn crops alone. We have fully illustrated it in the case of the turnip; and our unpublished evidence in regard to some other crops, goes in the same direction. The fact is indeed very important to bear in mind; for it constitutes an important item in our study of the variations which are found to exist in the composition both of the organic substance, and of the ash, of one and the same crop, grown under

Digitized by Google

different circumstances. We may particularly observe, that the obvious reduction in the percentage of nitrogen in wheat grain, the more, within certain climatic limits, the seed is perfected, is in itself a fact of the highest interest; and it is the more so, when we consider how exceedingly dependent for full growth, is this crop upon a liberal supply of available nitrogen within the soil.

Bearing in mind, then, the general points of relationship which have been established between the characters of the crop as to development and maturation on the one hand, and the percentage amounts of certain constituents on the other, let us now see—what is the general influence of characteristic constituents of *manure*, upon the characters and composition of our wheat crop, which is allowed to remain on the land until the plant has fulfilled its highest function—namely, that of producing a ripened seed?

In illustration of this point we have arranged in Table III., the same particulars as to general character of the crop, and as to the composition of the produce, from several individual plots during the ten years; instead of the average of the series in each year, as in Table I. The cases selected for the comparison are:—

1. A continuously unmanured plot;

2. A plot having an excess of ammoniacal salts alone every year;

3. The average of several plots, each having the same amount of ammoniacal salts as the plot just mentioned, but with it a more or less perfect provision by manure, of the *mineral constituents* also.

It would be impossible to give the detail supplying all the results collected in this Table; but perhaps it is only proper that we should do so, so far at least as the percentage of nitrogen in the dry substance of the grain is concerned.

Digitized by Google

TABLE II.

Determinations of Nitrogen per cent. in the Dry Matter of Wheat Grain grown at Rothamsted.

Harvests.	EXPERIMENTS.					Mean.
	1	2	3	4	5	
Unmanured.						
1845	2.28	2.21	2.33	2.30	.....	2.28
1846	2.11	2.12	.....	.....	.....	2.11
1847	2.11	2.08	2.22	2.22	.....	2.16
1848	2.33	2.34	2.32	2.37	.....	2.34
1849	1.85	1.83	1.91	.....	.....	1.86
1850	2.07	.....	2.10	2.07	.....	2.06
1851	1.80	1.74	1.89	1.76	.....	1.80
1852	2.31	2.23	2.38	2.31	.....	2.31
1853	2.26	.....	2.33	2.38	.....	2.32
1854	2.06	2.06	1.98	1.96	.....	2.01
Manured with Ammoniacal Salts Only.						
1845	2.18	2.29	2.22	2.23	.....	2.23
1846	2.18	2.12	2.29	2.19	.....	2.19
1847	2.35	2.29	2.42	2.32	.....	2.34
1848	2.39	2.41	2.39	2.49	.....	2.42
1849	1.89	.....	2.04	1.22	.....	1.95
1850	2.18	.....	2.08	2.19	.....	2.13
1851	2.15	2.12	2.09	2.25	.....	2.15
1852	2.41	2.50	2.44	2.58	.....	2.48
1853	2.43	2.48	2.37	2.44	.....	2.43
1854	2.31	2.22	2.31	2.37	.....	2.30
Manured with Ammoniacal Salts and Mineral Manure. (Mixed Plots.)						
1845	.....	.....	.....	.....	.....	.....
1846	2.20	2.14	.....	2.14	.....	2.16
1847	2.34	2.38	2.40	2.42	2.44	2.40
1848	2.36	.....	2.40	2.42	2.48	2.41
1849	1.96	1.97	2.10	2.07	.....	2.02
1850	2.16	2.28	2.25	2.25	.....	2.23
1851	2.00	1.98	2.02	1.92	.....	1.98
1852	2.43	2.34	2.31	2.40	2.32	2.36
1853	2.30	2.34	2.29	2.28	.....	2.30
1854	2.16	.....	2.12	2.07	.....	2.12

Digitized by Google

It is necessary to make a few remarks in reference to this Table of more than one hundred nitrogen determinations. They were made by the method of burning with soda-lime, and collecting and weighing as platinum salt in the ordinary way. Few, perhaps, who have only made a limited number of such determinations, then, only on pure and uniform substances, and who have not attempted to control their work at another period, with fresh re-agents, or by the work of another operator, will imagine the range of variation which is to be expected when all these adverse elements are to have their influence. It is freely granted, that the variations shown in the Table between one determination and another, on one and the same substance, are sometimes more than could be desired. The following, however, are the circumstances under which they have been obtained. Experiments one and two were pretty uniformly made by the same operator, but not all consecutively, or with the same batch of re-agents. It was thought, therefore, that independently of any variations between the two determinations, it would be desirable to have results, so important in their bearings, verified by others. Accordingly, samples of each of the ground grains were given under arbitrary numbers, to two other operators, and their results are recorded respectively in columns three and four; and where a fifth determination is given, it is a repetition by one or other of the experimenters last referred to. We should observe, that we have found it almost impossible to procure a soda-lime that will not give more or less indication of nitrogen when burnt with an organic substance not containing it; and hence we have at length adopted the plan of mixing one-half per cent. of non-nitrogenous substance intimately with the bulk of soda-lime, igniting it in a muffle, moistening and reheating it gently. After this treatment the soda-lime is free from ammonia-yielding matter. It should further be remembered, that a ground wheat-grain is by no means an uniform substance. Indeed, as we shall show further on, some of the particles of which such a powder is composed,

Digitized by Google

may contain half as much again of nitrogen as others; and thus any inefficiency in the grinding, or error in taking the portion for analysis, may materially affect the result. Notwithstanding all these circumstances, and the admitedly undesirable range of difference in the several determinations in some cases, it will be observed, that generally three at least of the numbers agree sufficiently closely, and in some cases the fourth also. In fact, after all, a study of the detailed table must give considerable confidence, at least in the direction of the variations between the *mean* results given in Table III., and in their sufficiency for the arguments founded upon them. With these remarks on the data, let us proceed with the discussion of the table itself.

A glance at this Table III., shows that the *quantity* of produce varies very much indeed in one and the same season, according to the manuring. With these great differences in the *quantities*, dependent on manuring, we have far less marked differences in the *quality* of this ripened crop, dependent on the same causes; and this, with some few exceptions, is the same whether we look to the columns indicating the general characters only, or the composition of the produce. That is to say, the same general distinctions between the produce of one season and another are observable under the several varying conditions of manuring in each, as have been exhibited in Table I. of averages alone. In fact, season or climate variations are seen to have much more influence than manuring, upon the character and composition of the crop.

We have said that, other things being equal, the percentage of nitrogen in our wheat grain was the lower the more the seed was perfected; and we have also said, that nitrogenous manures greatly aid the development of the crop. But, an inspection of the columns of Table III. (on next page), which give the percentages of nitrogen in the dry substances of the grains produced under the three different conditions of manuring specified, shows us that there is almost invariably a higher percentage of nitrogen, where ammoniacal salts alone have been employed, than where the crop was unmanured.

Digitized by Google

TABLE III.

	PARTICULARS OF QUANTITY.			PARTICULARS OF QUALITY.									COMPOSITION OF GRAIN.									COMPOSITION OF STRAW.								
	Total Produce (Corn and Straw) per acre in lbs.			Per cent. Corn in Total Produce.			Per ct. Dress'd Corn in Total Corn.			Weight per bushel Dress'd Corn in lbs.			Per cent. Dry (212°).			Per cent. Ash in Dry			Per cent. Nitrogen in Dry.			Per cent. Dry (212°.)			Per cent. Ash in Dry			Per cent. Nitrogen in Dry.		
	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts.	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts	Unmanured	Ammoniacal Salts only	Minerals and Ammoniacal Salts
1845	4153	6246	.....	34.7	31.7	.....	90.9	90.4	.....	56.5	56.2	.....	81.2	80.0	80.9	1.9	1.8	1·9	2.2	2.2	....	.....	.....	.....	....	....	....	....	0 9	....
1846	2720	4094	4666	44.4	45.2	42.4	94.7	94.1	93.6	63 7	63.6	63.1	84.0	85·2	84.1	2.0	1.8	1·9	2.1	2.1	2.1	.....	.....	.....	....	...	5·8	....	0.6	0.7
1847	3025	4593	5479	37.1	37.1	36.0	91.6	93.1	93.1	60.9	61.5	62.3	.....	.....	.....	....	....	....	2.1	2.3	2.4	.....	.....	.....	5.9	.5	5.3	0.7	0.7	0.7
1848	2664	3701	4661	35 7	36.0	36.5	88.8	83.9	89.3	57.3	58.1	58.7	.....	81.2	80.4	2.1	2.0	2·0	2.3	2.4	2.4	.....	.....	.....	8 0	6.7	7.0	0.6	0.8	0.8
1849	2843	4992	5619	43.2	42.9	40.5	96.1	94.8	95.4	61.4	62.3	63.7	82.3	82.7	83.0	1.9	1.7	1·8	1.8	1.9	2.0	82.1	83.9	82.5	7 2	6.1	5.9	0.8	0.8	0.8
1850	2721	4810	5877	36.8	35.8	33.2	95.6	94.2	94.2	60.6	60.2	61.2	83.8	84.3	84.4	2.0	1.9	2·0	2.0	2.1	2.2	82.6	85.7	84.4	7.2	5.4	5.6	0.8	....	0.9
1851	2710	5036	5583	40.0	30.0	38.1	89.5	91.0	92.3	61.1	61.9	62.6	84.3	84.5	84.0	1.9	1.8	1·8	1.8	2.1	1.9	84.3	84 9	84 4	6.7	5.5	5.6	0.7	....	0.8
1852	2457	4107	4970	35.0	32.1	30.6	90.0	92.6	92.1	56.6	55.9	56.5	82.6	83.7	83.5	2.1	1.9	1·9	2.3	2.4	2.3	82 8	83.3	82 6	7.4	5.8	5.9	0.9	0.6	0.7
1853	1772	2691	4913	20.2	23.8	26.8	74.3	75.2	89.5	45.9	48.6	51.9	80.1	80.4	80.9	2.5	2.0	2·1	2.3	2.4	2 3	81.6	80.9	81.2	6.5	6.1	5.0	1.2	1.2	1.0
1854	3496	5808	8311	38 9	38.1	34.7	93.9	94.0	95.6	60.6	60.5	61.9	84.7	84.8	85.1	2.0	1.7	1·8	2.0	2.3	2.1	83.8	84.3	84.1	5.2	4.7	4.9	0.7	0.5	0.7
	2856	4608	5564	36.6	36.2	35.4	90.6	90.3	92.8	58.5	58.9	60.2	82.9	83.0	82.9	2.0	1.8	1.9	2.1	2.2	2.2	82,8	83.8	83.2	6.8	5.7	5.8	0.8	0 8	0.8

Digitized by Google

We also see that, almost invariably, there is a higher percentage of nitrogen where mineral manures as well as ammoniacal salts have been used, than in the produce of the corresponding unmanured plots. A closer examination shows, however, though the indication is not uniform, that there is, nevertheless, an obvious tendency to a lower percentage of nitrogen, where the mineral constituents also have been employed, than where the ammoniacal salts have been used alone; and with this there is, on the average, a somewhat higher weight per bushel, indicating higher degree of maturation. Then, again, what are the circumstances of these experiments, under which an increased percentage of nitrogen in the fixed substance of the produce, is obtained by a supply of it in manure? The unmanured plot, with its low percentage of nitrogen in produce, is shown by the field experiments, to be greatly exhausted of the annually available nitrogen, relatively to the annually available mineral constituents required by the wheat crop. The plot, with the ammoniacal salts alone, is shown by the field results to be defective in the requisite and available minerals, relatively to the available nitrogen, and hence the crop is grown under a relative excess of the latter. Again, the plots with mineral manures and ammoniacal salts together, received so far an excess of the latter, as to yield, with the minerals, a larger crop than the average of the locality under rotation, and larger also than the average of seasons would ripen healthily. It is then, under these artificial and abnormal circumstances, of the somewhat unnaturally low percentage of nitrogen, from obvious defect of it in relation to the developing and maturing capabilities of the season on the one hand, and the obviously relative excess of it on the other, that we got an increased percentage of nitrogen in wheat-grain by the use of it in manure. Even under these extreme conditions, the range of variation by manuring is very small; and there is nothing in the evidence that justifies the opinion, that, within the range of full crops and healthy maturation, the percentage of nitrogen in wheat-grain, can

Digitized by Google

be increased at pleasure by the use of it in manure. That very opposite extremes of condition of soil-supply, may directly influence the composition even of wheat-grain, is however illustrated in the percentages of mineral matter, as well as those of nitrogen, given in the table. Thus, taking the mean results only, we have, with the relative excess of mineral constituents on the unmanured plot, the highest per cent. in the produce; with the greatest relative defect on the plot with ammoniacal salts only, the lowest per cent. in the grain; and with the medium relation in the other plots, the medium per cent. in the produce. Excepting, however, abnormal conditions, as already remarked, variation in climatic circumstances, has much greater influence on the percentage-composition of wheat-grain, than variation in manuring.

Let us now turn to the composition of the *ash* of wheat-grain. Independently of the defect of a sufficient number of published analyses of wheat-grain ash, a dozen years ago, when we took up the subject, it was then generally believed that the composition of the ash of vegetable produce, would vary considerably with the supplies of the different constituents in the soil; it was thought, indeed, that according to the abundance of their presence, one base might substitute another, as for instance, *soda*, *potash*, and so on. About the same time that we undertook a series of wheat-ash analyses, the ashes of various succulent vegetables were also analysed. This latter investigation led us to conclude, that the fixity of the composition of the ash of such substances, depended very much upon the degree of maturation of the produce; and in fact that some constituents—soda and chlorine for instance—occurred in much larger quantities in the more succulent and unripe, than in the more elaborated specimens. It seemed to be perfectly consistent with this experience, to find in the ash of a comparatively perfected vegetable product like wheat-grain, a considerable uniformity of composition—such indeed as the analyses now to be recorded will indicate.

These analyses were made ten years ago by Mr. Dugald

Digitized by Google

Campbell, and the late Mr. Ashford. And as, since that time, the methods of ash-analysis have in some points been improved upon, it will be well to give an outline of the plan then adopted: especially as it is by a consideration of the tendencies to error on some points, that we must interpret the bearings of the actual figures given. On this point we need only add, that Mr. Campbell fully concurs in the tenor of our remarks.

Method of Analysis:—Three portions of ash were taken.

No. 1. In this the sand, silica, and charcoal, phosphate of iron, phosphoric acid, lime, and magnesia, were determined. The ash was dissolved in dilute hydrochloric acid, evaporated to perfect dryness, moistened with hydrochloric acid, boiled with water, and the insoluble matter collected and weighed, as—*sand*, *silica*, and *charcoal*. To the filtrate, acetate of ammonia was added after digestion, the precipitate separated, dried, ignited, and weighed—as *phosphate of iron*. To the filtrate now obtained, a solution of a weighed portion of pure iron dissolved in nitro-hydrochloric acid was added, then acetate of ammonia, and the mixture digested until the whole of the iron was precipitated as phosphate of the peroxide with excess of peroxide from which was calculated the *phosphoric acid*. From the solution filtered from the phosphate of iron and oxide of iron, the *lime* was separated as oxalate and ignited as carbonate; and from this last filtrate, the *magnesia*, by phosphate of soda and ammonia.

No. 2. A second portion of ash was put into a carbonic acid apparatus, the acid, if any, evolved by means of nitric acid, and determined by the loss. The solution being filtered, sulphuric acid was separated by nitrate of baryta; and afterward *chlorine* by nitrate of silver.

No. 3. To a solution of a weighed portion of the ash in hydrochloric acid, caustic baryta was added in excess, and the precipitate separated by filtration; the excess of baryta was then removed by carbonate of ammonia, and the filtered solution evaporated to dryness, the residue heated to redness and

Digitized by Google

weighed; water added, any insoluble deducted, and the remainder taken as chlorides of potassium and sodium; a solution of chloride of platinum was now added to separate the *potash;* the *soda* being calculated from the loss.

It is now admitted, that the separation of phosphate of iron from the earthly phosphates by acetates of ammonia as above described, is unsatisfactory; and it is probable the amounts given in the tables as phosphate of iron are too high, and if so, part of the difference should obviously go to the earthy bases. For a similar reason, it is possible that the phosphoric acid determinations may be somewhat too high—also at the expense of the earthy bases. Then, again, it is well known that in practice the process for potash and soda is one of some delicacy; and that the tendency of manipulative error is to give the soda somewhat too high. We conclude upon the whole, that our phosphoric acid determinations *may* be somewhat high; our phosphate of iron pretty certainly so; and probably the soda also; the other bases being, on this supposition, given somewhat too low.

The wheat-grain ash-analyses, twenty-three in number, and referring to the produce of three separate seasons, and of very various manuring, are given in the following tables—numbered IV., V., and VI. respectively.

Digitized by Google

TABLE IV.

Analysis of Wheat-Grain Ash.—Harvest 1844.

Plot Numbers	2	3	5	1	9		15	16	18	Means.
Manuring, per acre	Farm-yard Manure—14 tons.	Unmanured.	Superphosphate Lime 700 lbs.	Superphosphate Lime 700 lbs. Rape Cake, 150 lbs.	Superphosphate Lime, 616 lbs. Sulphate Ammonia, 65 lbs.		Superphosphate Lime, Potash, and Magnesia, and Silicate Potash.	As 15, with soda and Sulphate Ammonia, 65 lbs.	As 16, in Rape Cake, 154 lbs.	
					Analysis 1	Analysis 2				
Characters of the Produce:										
Per Cent. Corn in Total Produce	46.4	45.2	46.1	46.4	48.3		46.9	46.8	48.6	46.2
Weight per bushel of Dressed Corn (lbs.)	59.2	58.5	58.2	59.0	62.2		62.0	62.5	62.0	60.4
Per Cent. Dry Substance in Corn (at 212°)	82.8	81.8	81.1	82.3	83.6		83.1	83.3	83.2	82.65
Per Cent. Ash in Dry Substance	2.06	2.17	2.25	1.88	2.00		2.02	2.08	1.96	2.05
Constituents of Ash:										
Phosphoric Acid	48.13	50.84	51.02	50.48	49.92	49.98	50.89	51.48	49.28	50.16
Phosphate of Iron	2·56	2.45	2.62	2.10	2.32	2.55	3.00	2.54	2.75	2.54
Potass	28.91	30.22	29.37	27.40	29.06	29.45	29.09	28.33	28.53	28.93
Soda	.76	.00	.22	1.12	.90	.00	.00	.00	2.10	.57
Magnesia	11.84	11.04	11.81	10.10	10.84	10.36	10.86	11.38	11.38	11.07
Lime	3.77	3.00	3.18	2.71	3.39	3.78	3.17	3.31	3.48	3.30
Chlorine	Traces.	.12	Traces.	.52	.15	.11	.09	.21	Traces	.13
Silica, Sand, and Charcoal	2.64	2.72	1.49	5.45	2.57	2.21	1.86	1.47	1.70	2.45
Totals	98.61	100.39	99.71	99.88	99.15	98.39	98.46	98.67	99.22	99.15

Digitized by Google

TABLE V.

Analysis of Wheat-Grain Ash.—Harvest, 1845.

Plot Numbers	2	3	5 A	5 B	6	15	17		Means.
Manuring per acre	Farm-yard Manure, 14 tons.	Unmanured.	Superphosphate Lime in 1843-4. Unmanured.	Superphosphate Lime in 1843-4. Carbonate Ammonia (Solution.)	Superphosphate Lime, 112 lbs. Sulphate Ammonia 112 lbs. Rape Cake 560 lbs.	Bone-ash 224 lbs. Hydrochloric Acid 224 lbs. Sulphate Ammonia 224 lbs.	Superphosphate Lime 112 lbs. Sulphate & Muriate Ammonia each 112 lbs. Rape Cake 280 lbs. Analysis 1	Analysis 2	
Characters of the Produce:									
Per Cent of Corn in Total Produce	33.4	34.7	34.8	32.5	33.9	34.2	35.4		34.18
Weight per bushel of Dressed Corn (lbs.)	56.7	56.5	57.5	57.2	57.7	57.5	55.7		56.97
Per Cent. Dry Substance in Corn (at 212°)	80.0	81.2	81.1	80.9	81.7	80.9	80.6		80.91
Per Cent. Ash in Dry Substance	1.89	1.93	1.88	1.98	1.92	1.91	1.92		1.92
Constituents of Ash:									
Phosphoric Acid	47.08	48.69	45.69	47.81	51.56	50.26	51.34	50.01	49.05
Phosphate of Iron	1.97	2.81	3.66	4.58	1.22	1.07	.80	1.20	2.10
Potass	25.16	28.53	29.06	28.87	31.75	32.27	30.20	30.47	29.54
Soda	8.01	.00	6.19	5.01	.00	.00	.68	.00	2.49
Magnesia	11.06	11.58	9.57	8.98	10.14	10.00	10.65	9.96	10.24
Lime	3.66	3.57	3.39	2.02	3.20	3.36	3.06	3.16	3.18
Chlorine	.00	.20	.00	.00	Trace	Trace	.40	.23	.10
Silica, Sand and Charcoal	3.29	3.39	1.45	1.68	2.36	2.21	2.61	3.40	2.55
Totals	100.23	98.27	99.01	98.95	100.22	99.17	99.74	98.48	99.25

Digitized by Google

TABLE VI.

Analysis of Wheat-Grain Ash.—Harvest, 1846.

Plot Numbers	2	3	1	8B	4	11 B	Means.
Manuring per acre	Farm-yard Manure, 14 tons.	Unmanured.	Bone-ash 224 lbs.	Bone ash 224 lbs. Sulphate and Muriate Ammonia each 112 lbs.	Bone ash 224 lbs. Hydrochloric Acid 224 lbs. Sulphate Ammonia, 224 lbs.	Bone-ash 224 lbs. Sulphuric Acid 224 lbs. Sulphate and Muriate Ammonia each 112 lbs.	
Character of the Produce:							
Per Cent. Corn in total produce	42.7	44.4	43.6	43.6	42.6	43.1	43.8
Weight per bushel of Dressed Corn (lbs.)	63.0	63.7	62.6	63.6	63.5	63.2	63.8
Per Cent. Dry Substance in Corn at (212°)	84.1	84.0	83.8	84.5	84.8	83.9	84.1
Per Cent. Ash in Dry Substance	2.07	2.08	2.04	1.91	1.99	1.91	1.99
Constituents of Ash:							
Phosphoric Acid	50.01	49.89	50.62	49.47	48.78	50.08	49.80
Phosphate of Iron	1.65	1.66	3.10	2.52	2.62	3.06	2.43
Potass	30.03	30.60	27.98	29.58	31.00	29.18	29.72
Soda	.35	.25	.00	.00	.00	.00	.10
Magnesia	11.03	10.97	10.79	11.13	10.43	10.34	10.78
Lime	*2.98	*2.89	4.04	4.63	4.31	4.22	3.84
Chlorine	.12	09	.30	.34	Traces	.17	.17
Silica, Sand and Charcoal	1.88	2.17	2.18	2.54	2.62	3.00	2.40
Totals	98.05	98.52	98.96	100.21	99.71	100.05	99.24

* It would seem probable that in these two cases the Lime is given too low; but as the analyst, Mr. Ashford, is dead, no reference can be made, and we have unfortunately not had time to repeat the analysis prior to publication, as intended.

Digitized by Google

It is at once seen, that this ash may be reckoned to contain neither sulphuric acid, carbonic acid, nor chlorine. The latter at least occurred only occasionally, and then in such small quantities as to lead us to the supposition that its presence is accidental, or at any rate not essential, in the ash of a perfectly ripened grain. From the frequent absence of soda again, and from the uncertainty in its determinations as above alluded to, we are led to look at it as an equally unessential ingredient in the grain-ash of perfectly ripened wheat. Excluding then the chlorine, the soda, the iron of the phosphate of iron, and that portion of the matter collected as insoluble, which may have been soluble silica—the whole of these, on the average, amounting to a very few per cent.—the ash of wheat-grain is seen to consist essentially of *phosphates only;* the bases being potash, magnesia and lime. The potash amounts to nearly one-third of the whole ash; the magnesia to rather more than one-third of the potash; and the lime to about one-third of the magnesia.

If we now compare with one another the analyses of the eight different ashes in 1844, those of the seven in 1845, or of the six in 1846, having regard to the manures by which the crops were grown, it is impossible to say that these have had any direct and well-defined influence upon the composition of the ash of the grain. Thus we find, looking at the Table for 1844, that several of the plots manured with super-phosphate of lime, yield a grain-ash having no higher percentage of phosphoric acid than that of the unmanured plot. Again, where potash is added (plots 15, 16 and 18), the percentage of it in the ash is not greater than the average of the cases where it was not employed. And again, in the only case where soda was employed (plot 16), there is none of it found in the ash; nor, lastly, is the percentage of magnesia obviously increased by the use of it in manure. A similar detailed consideration of the composition of the ashes of the seasons of 1845 and 1846, would, as already intimated, lead to a similar conclusion. In fact, the variations in the composi-

Digitized by Google

tion of the ash of this supposed ripened product, according to the manure by which it is grown, seem to be scarcely beyond the limits of error in the manipulation of the analysis; though, one case at least of the duplicate analysis of the same ash—namely, that of No. 9, 1844—indicates the range of variation from this cause to have been but small; in the other (No. 17, 1845), it was somewhat greater.

Although the accuracy of the analyses may not be such as to show the difference in composition, if any, dependent on *manure*, yet it is found to be quite adequate to indicate the marked differences in the *degree of development and maturation* of the grains, dependent upon *season*. Before calling attention to the figures illustrating this point, it should be remarked that the season of 1845 was the worst but one, and that of 1846 nearly the best, for ripening the grain, during the thirteen years of our continuous growth of wheat. And we shall find, consistently with this, and with the conclusions arrived at in connection with Tables I. and III., that the variation in the composition of the ash is, comparing one year with another, much the greatest in the produce of the bad ripening season 1845, and much the least in the good ripening season 1846. This point, and some others are illustrated in the following Summary Table, No. VII.

Digitized by Google

TABLE VII. COMPOSITION OF WHEAT-GRAIN ASH.

	Variation in per Cent. in each Season.			Mean for each Season.			Means acording to Manuring.			General Means.	
	1844. 9 Cases.	1845. 8 Cases.	1846. 6 Cases.	1844. 9 Cases.	1845. 8 Cases.	1846. 6 Cases.	Unmanured (3 y'rs.)	Farm-yard Manure (3 y'rs.)	Other Manures (3 years) 17 Cases.	23 Cases Rothamsted.	26 Cases Mr. Way
Characters of the produce:—											
Per Cent. Corn in Total Produce,	.....	.....	.....	46.2	34.1	43.3	41.4	40.8	41.3	41.2	
Weight per bushel of Dressed Corn (lbs.),	.....	.....	.....	60.4	57.0	63.3	59.6	59.6	60.1	60.0	
Per Cent. Dry Substance in Corn (at 212°),	.....	.....	.....	82.6	80.9	74.1	82.3	82.3	82.5	82.4	
Per Cent. Ash in Dry Substance,	.....	.....	.....	2.05	1.92	1.98	2.04	2.01	1.97	1.99	1.69
Composition of Ash:—											
Phosphoric Acid,	3.30	5.87	1.89	50.16	49.05	49.80	49.81	48.41	49.88	49.68	45.01
Phosphate of Iron,	.90	3.87	1.45	2.54	2.10	2.48	2.14	2.06	2.45	2.36	0.82*
Potass,	2.82	7.11	3.07	28.93	29.54	29.72	29.78	28.03	29.50	29.35	31.44
Soda,	2.10	8.01	.35	.57	2.49	.10	.08	3.04	.95	1.12	2.71
Magnesia,	1.74	2.60	.79	11.07	10.24	10.78	11.20	11.31	10.51	10.70	12.36
Lime,	1.06	1.64	1.74	3.30	3.18	3.34	3.15	3.47	3.43	3.40	3.52
Sulphuric Acid,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.34
Carbonic Acid,	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.02
Chlorine,	.....	.....	.....	.13	.10	.17	.14	.04	.14	.13	.13
Silica, Sand, and Charcoal,	.....	.....	.....	2.45	2.55	2.40	2.76	2.60	2.41	2.47	3.67†
Totals,	.....	.....	.....	99.15	99.25	99.24	99.06	98.96	99.27	99.21	100.08

* Peroxide of Iron. † Mr. Way gives this as soluble silica, exclusive of the sand and charcoal included with it in our own analyses.

Digitized by Google

Looking at the first Division of this Table VII., it is seen that in the item of *phosphoric acid*, the variation in the percentage among the several cases in each year, is the greatest in 1845, and the least in 1846; in the *phosphate of iron*, it is the greatest in 1845; in the *potash*, it is the greatest in 1845, much less and about equal, in 1844 and 1846; in the *soda*, it is much the greatest in 1845, and much the least in 1846; in the *magnesia*, it is again far the greatest in 1845, and it is the least in 1846. In the case of the *lime*, we have an exception to this general indication, dependent on the two low amounts of it given for Nos. 2 and 3, 1846; but if these are really in error in the direction suggested at the foot of Table VI., the indication would be the same as for the other constituents. We have then in the circumstances of the seasons, and in the comparative characters of the produce coincident with these variations, the evidence that for one and the same description of grain, in a perfectly matured condition, the composition of the ash will be, within certain narrow limits, constant.

So far as the constituents of the ash of the entire grain of wheat is concerned, we have only further to call attention to the three other Divisions of this Summary Table No. VII. In these are shown, side by side:

In the second Division of the Table, the mean composition of the ashes for each of the three separate years;

In the third Division, the mean composition for the three years together: (*a*) of the grain-ash from the unmanured plot—(*b*) of that from the farm-yard manured plot—(*c*) of the grain-ashes from all the other manures during the three years, including 17 cases; and

In the fourth and last Division, the mean composition of all our own wheat grain-ashes analyzed, 23 in number, by the side of the mean of 26 analyses of the grain-ashes of wheat, of different descriptions or grown in different localities, published by Mr. Way.

We will go into very little detail discussions of these mean results, as the points they illustrate have most of them already

Digitized by Google

been alluded to. We may first remark, that the mean percentage of *lime* is the least in the bad year 1845, and the greatest in the good year 1846. Again, it is greater in the average from the manured plots, than in that from the unmanured. We may perhaps here anticipate by saying, that this is at any rate consistent with what we shall afterwards have to record, namely, that the ash of the finer flour—of which there is a greater proportion in the grain of the seasons of best maturation—contains more lime than that of the coarser and more branny portions of the grain.

Lastly, in reference to this Summary Table, we would call attention to the mean composition of wheat-grain ash yielded by the twenty-six analyses given by Mr. Way, by the side of that of the twenty-three specimens grown at Rothamsted. Mr. Way's analyses, equally with our own, show that wheat-grain ash essentially consists of phosphates of potash, magnesia, and lime. He, however, if we exclude silica, gives higher percentages of base, and a lower one of acid, than our own analyses indicate. Mr. Ways' average amount of phosphoric acid is indeed nearly five per cent. less in the ash than ours. His series, however, included many descriptions of wheat, and our own only one—the Old Red Lammas. In several of his cases, too, we observe that the percentage of this acid very closely approximates to our own average."

Digitized by Google

CHAPTER XI.

GROWTH OF THE WHEAT PLANT.

HAVING discussed the chemical doctrines of vegetable life, so far as the wheat plant is concerned, in our preceding remarks, we will now proceed to describe the process of germination, development, and maturation during, and by the agency of which, those inorganic elements, destined for the food of men and animals, after preparation by means of the plants, are collected and combined. It is the especial province of plants so to combine and arrange the inorganic elements of which all animal bodies are composed, as to fit them for reception into, and assimilation in these organisms, and every matter connected with such important functions can not fail to be an interesting subject for investigation.

The ripe, well-formed, and fully developed wheat grain, magnified to six times its average size, is seen in figure 10.

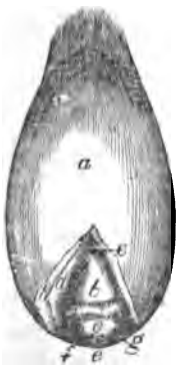


FIG. 10.

The appearance of such a grain is so familiar as to require only a passing notice. At one end of the berry, which is somewhat egg-shaped, with a longitudinal groove in one side, a number of short hairs or bristles are seen, and at the other, the scar or point at which the grain was attached to the parent stem. Near this point on the convex side of the grain, is a spot marking the position of the embryo or organs of germination, or the germ itself, known in common parlance as the "*chit*." This germ spot may be studied by the aid of Fig. 10, which is a magnified view of a wheat grain with the bran removed from where it covers the germ externally. *a* marks the body of

Digitized by Google

the grain where the greater portion of the starch or flour is deposited, *h* the edge of the outer covering of the grain, *d* the proper envelop of the germ. *e e e* is the germ, and as the use of this is a subject of interesting inquiry, we will dwell upon its form and office for a moment. The same principle which obtains in the germination of a grain of wheat obtains also in the germination of all other seeds, and the only discoverable difference between the germs of one plant or seed and those of another, is a slight difference of anatomical arrangement, which has given rise to the grand division of plants, by botanists, into monocotyledonous and dicotyledonous classes.

The cotyledon is best studied perhaps in the bean or pumpkin, and is in the seeds of these and many other plants made up of the halves of the seeds which adhere to the plumule, or first sprout, which emerges from the ground in the form of thick, green, ovate leaves, and being two in number, they give origin to the name *dicotyledon*. The use of these cotyledons is to give nourishment to the developing germ until able to draw its food from the earth. Plants, among which is wheat, having no division of the seed into halves as the bean, acorn, etc., are styled monocotyledons, from this fact—but whether the cotyledons be single or double, it has physiologically the same purpose to accomplish, that is, supplying the germ, which represents in itself the yet to be perfect plan, with the nutrient materials stored away in the form of starch, gum, oil, etc. in the grain or seed, and upon the perfect performance of which function the health of the new plant mainly depends. The germ Fig. 10, *e e e*, representing the future plant, consists of three principal parts. First, the portion yet to be developed as the plumule or ascending sprout *c*, *b*; second, the part *e e*, from which the radicle or first rootlet is developed; and third, a band bisecting the germ, which is the crown of the roots, or division line between the roots and stalk, and which in some plants represents the stem or trunk of the future tree. *f*, *e*, *g*, is that part which becomes developed as

Digitized by Google

a root, first *e*, the radicle, which after a short life, having served its purpose as a root, is generally re-absorbed, being a rudimentary part and then *f*, *g*, the first two permanent roots spring forth, the whole presenting in a few days after exposure to the proper conditions the appearance indicated in Fig. 8.

A grain of wheat being deposited in the earth, water is supplied to it from the soil, which it absorbs, and all the contents of the berry soften, swell and undergo certain changes, chemical and chemico-vital, which result in the process of germination being begun and carried on. The germ described, Fig. 10, being supplied by moisture, calls into activity the life-forces which hitherto lay dormant. The starch, gluten, salts, etc., contained in the seed as a store of nutriment for the beginning plant, are softened, chemically changed, dissolved and fitted for absorption into it, and are taken up by it as required to complete its embryotic, so to say, growth.

After a short time the developing germinal plant, and the parent grain assume the appearance presented in Fig. 8, in which *a* refers to the plumule, *ascending axis*, or first green leaf, *h h h*, to the origin of the primary and two secondary radicles F E, C, E. The part of the grain marked B is that which contains the larger part of the starch and other food of the plant, while D is the part containing all that is *absolutely* necessary for germination. C, E, the primary radicle is marked by several protuberances, *o o o o* called *spongioles*, Fig. 9, whose office it is to absorb water, and the materials dissolved in it from the earth, for the sustenance of the plant, and terminates in a like spongiole E, by the changes of and additions to which the root continually grows

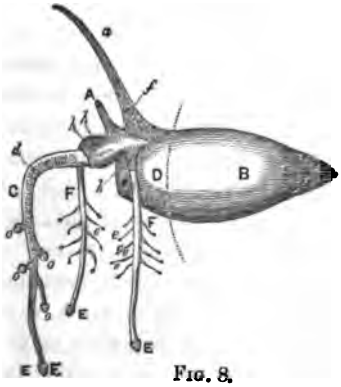


FIG. 8.

Digitized by Google

until maturity is reached. Along the course of the secondary roots F, E, terminating like the primary root, in a spongiole, are seen little branching rootlets *e e e*, each of which also terminates in a spongiole, Fig. 9. A second plumule, A, Fig. 8, starts out from the base of the radicle and shows the commencement of that process known as stooling or tillering, which results in a vast multiplication of stems arising from one grain. This process does not take place, until the plant is firmly fixed in its place.

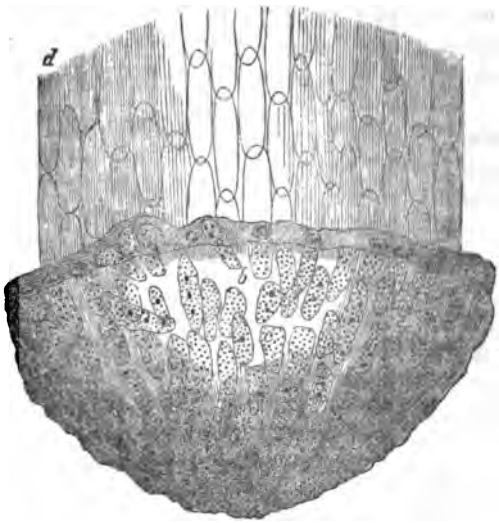


Fig. 9.

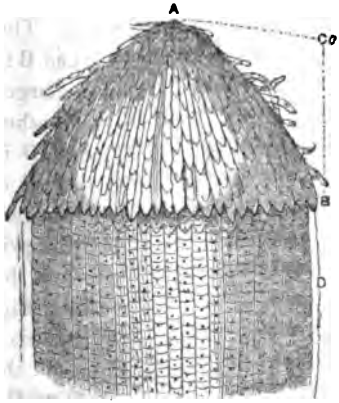


Fig. 11.

At this stage, Fig. 8, the young plant begins to absorb from the earth the materials for further growth, and hence the important practical application of the knowledge of the chemistry of the soils and plants growing upon them, to which we have adverted, that is to choose soils in which the necessary materials are found or to supply them if lacking for any given kind of vegetable product.

Digitized by Google

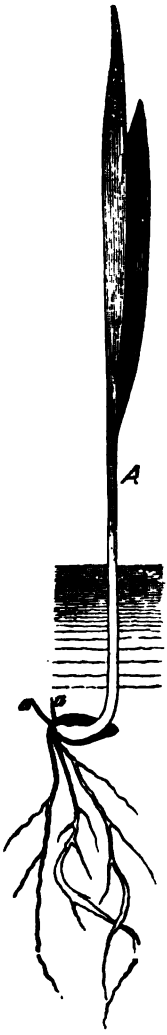


Fig. 13.

In Fig. 11 we have a largely magnified view of the summit of the plumule Fig. 8, *a*, which becomes developed in the wheat into the first perfect leaf. This delicate point is made up of little cells flattened by pressure, and applied to each other in nearly parallel lines, and by the breaking down or absorption of the adjacent walls of these cells, at the sides which occupy the axis of length, and by means of further depositions and alterations, they form little ducts for the transmission of sap or the *blood* of the plant.

After a certain time passed, from the deposit of the seed in the ground varying with the depth at which it was sown, the condition of the soil and air as to heat, moisture, etc., the seed represented as it is sown, Fig. 10, and the same shown in the process of germination, Fig. 8, presents the appearance shown in Fig. 14 or Fig. 13. In Fig. 13 we have an example of wheat deposited at a proper depth, averaging about one inch and a half. It is vigorous and thrifty, and shows this in the perfection of its roots and top. A, the stem, is now above above ground, surmounted by two leaves instead of the single plumule, which is now developed into the first perfect leaf which serves as an involucre to

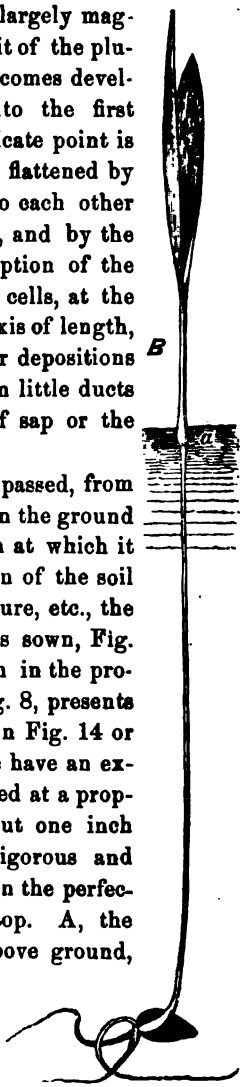


Fig. 14.

Digitized by Google

the second, which has emerged from it as from a sheath, and where it at first replaced the first plumule of the germ. Within the convolutions of the base of this leaf we will hereafter find another, and thus from the center, springs forth each new leaf, and the part of the stock belonging to it forming a joint at each leaf, until at last the top joint or that bearing the head is developed.

FIG. 15.

In Fig. 13, *a a*, are to be seen two new plumules, and these like the first one, become, when at a depth not exceeding one inch, new stalks, and are again succeeded by others, until a large number of stems, connected together it is true, at the root, but capable of separation into independent stalks having their proper roots, are produced, and thus undergo the process of *tillering* or multiplication of stems from one root, Fig. 15. This is a very important function for the production of cereals, and by means of carefully and frequently repeated divisions of the different stems to promote *tillering* to a great extent, over fifteen hundred grains have been obtained from a

Digitized by Google

single seed. It is to favor this process that drilling is used instead of broadcast sowing and harrowing, as the exact depth of deposit most favorable to this process differing somewhat in different soils, can be easily secured for every grain sown, while the harrow, covering the grain very unequally, gives it either too great or too shallow a depth, preventing in either case the accomplishment of this desirable object. The depth proper to secure this process is about two inches in light porous soil, and not more than one or one and a half inches in stiff clayey soil.

The effect of too great a depth in sowing is shown in Fig. 14. The stalk B. surmounted by its first two leaves is small and unthrifty as contrasted with a plant sown at proper depth, Fig. 13. The great distance which it was necessary for the plumule to traverse, before emerging into the air and sharing the vitalizing influence of the light has entirely exhausted the store of nutritious materials, furnished by the seed before it could attain sufficient development to be considered a healthy, vigorous plant, and therefore, its future growth is retarded, tillering, as seen in Fig. 15, is entirely prevented, and the stalk is more in danger of disease and accident and its loss in the field is irremediable.

At *a*. Fig. 14, just below the surface of the earth, is seen a nodule or enlargement of the stalk, and here new roots are generally thrown out if the vital force of the plant is not too far spent in reaching the surface, and the sickly, puny root, which should have sustained it is lost, as it dies and rots. Nature is ever on the alert to preserve every one of her progeny, and in this instance endeavors to repair as far as possible the evils resulting from ignorance or accident.

During the early part of the growth of the wheat plant, or during the fall and early winter, the absorption of silica in the form of a soluble silicate of potassa, is principally effected, and is a matter of vast importance in the physiology of the plant, and it is, perhaps, owing principally to this fact that winter wheat generally succeeds better than spring wheat,

Digitized by Google

which is not so favorably conditioned for absorbing this necessary constituent of the stalk, leaves and seeds, in all of which it is deposited during the last sixty days of growth, forming a large part of the thin pellicle or epidermis of all these parts, and greatly aids in protecting them from various accidents and diseases.

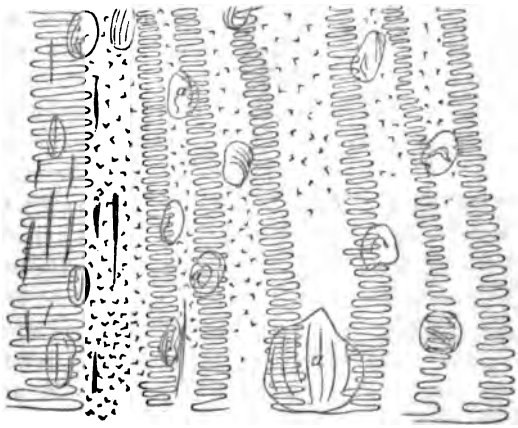


FIG. 16.

The manner in which this silica is deposited in the epidermis of wheat is represented in Fig. 16, which is a largely magnified section of a wheat glume; *a a a*, being thin scales of silica.

Winter-killing, a subject of frequent complaint among agriculturists, is perhaps of next importance in considering the growth of wheat, and is caused in the manner described as follows: When wheat is too deeply sown, the roots are comparatively few, as mentioned when speaking of that subject, and the plant is, consequently, more liable to perish than if it could afford, on account of a great number, the loss of a few roots. When the ground freezes during the winter, and particularly when it freezes and thaws many times, as is sometimes the case in Ohio, it becomes cleft at each freezing,

Digitized by Google

and the ends of the roots extending across this cleft are torn asunder, and in this manner the means of sustenance are denied to the plant during the spring, and on account of this rupture of its roots, it either perishes entirely or only retains vitality enough to carry on a sickly, feeble, unprofitable development.

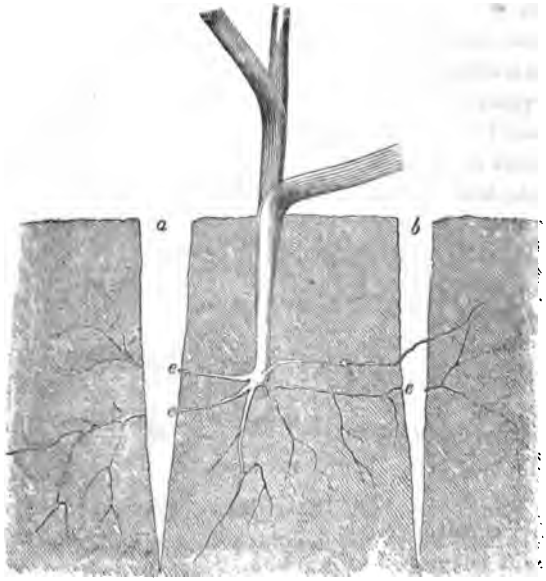


FIG. 17.

Fig. 17. Wheat plant in clay soil.
a, *b*. Cracks in soil caused by drought.
e e e. Roots ruptured by the induration of the soil.

Fig. 17 represents the cracking of the ground in stiff clay soil during drought; but may also serve to illustrate one of the modes in which frost operates to break and destroy the roots. The water from snows and rains during the winter, settles in and fills up the fissures as at *a* and *b*, the water then becomes ice, and in the process of freezing, sunders or breaks the roots by expansion. The water also finds its way into

Digitized by Google

lateral crevices, as from *e e* to *e*, and then, when freezing takes place, the plant is by this action not only thrown up, but the roots are severed. So long as the roots remain entire or unbroken the action of the frost does not injure, but the moment they are severed, their communication with the spongiole (Fig. 9) is interrupted, and although this interruption or breaking does not deprive them of vitality, it yet greatly retards the growth of the plant. If properly situated the parent plants put forth new roots from the terminals *e e e*, and if the spring is favorable, the plant produces at least half as much as if not winter-killed. But if the plant is thrown *entirely* out of the ground by the frost, it can not send forth new roots, and consequently dies.

The most effectual mode of preventing this occurrence, so far as the skill of the husbandman is concerned, is to underdrain, in an effectual manner, all the spots where wheat has been observed to be winter-killed, and then to plant at a proper depth to favor the development of a large mass of roots, and also the process of tillering. This depth is undoubtedly most certainly secured by using a properly constructed drill. If a grain be properly covered, the crown of the roots is well developed, as in Fig. 18, and the roots and rootlets are multiplied in number, and are nearer to the surface of the earth, and do not traverse so large a mass of soil downward, and are, therefore, proportionally less liable to rupture during heavy frosts, and can, at the same time, better spare the few which may be broken. By referring to works on the subject of draining, the reader will observe that properly constructed drains are also recommended as beneficial adjuvants in the prevention of winter-killing.

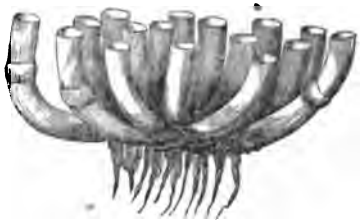


FIG. 18.

Nature's preventive is an early and durable blanket of

Digitized by Google

snow, and besides, the kind of soil has much to do in preventing or causing winter-killing. But these natural accessory causes are not within the control of the farmer.

When spring arrives, a new era in the growth of the wheat begins. During the fall and winter, it does not arrive at a point of development sufficiently advanced to shoot forth a stalk, but has been solely occupied in developing roots and leaves, and elaborating some of the materials, as silica, for future use.

But as soon as the frost has left the ground, and the warmth of spring permits, a new impetus is given to the growth of the plant,—roots are prolonged in every direction, to gather materials from the earth,—leaves expand and increase the power of the plant to effect those chemico-vital changes necessary to convert the inorganic elements and their compounds, which form its food, into its own tissues of growth and reproduction.

Carbonic acid, water, ammonia, potash, lime, and the oxides of the necessary metals, are collected as dissolved in the water of the soil, by the *spongioles* of the roots and rootlets, and conveyed by means of little tubes or canals, such as mentioned when speaking of the plumule, Fig. 11, to the leaves, there to be exposed to the influences of light, heat, and oxygen, and from these are returned and deposited in all parts of the plant, as its proper development requires.

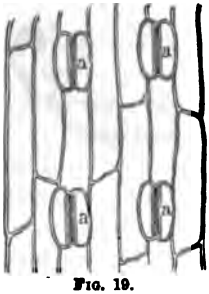


FIG. 19.

It may be well to mention, while passing, that an idea very strongly advocated a few years since, and supported by seemingly conclusive experimental evidence, to-wit: that plants gathered the materials of their growth principally from the air, directly, and not from the ground, is a fallacy. Air holds very nearly the same relation to plants as it does toward animals,—that is, elements in it, combined or simple, are ultimately necessary for the subsistence of either organism, but except oxygen, all these elements must be in a state of combination before the animal can feed upon

Digitized by Google

them, and even the oxygen is required to be combined with carbon before the plant can use either as food.

Ammonia, nitric acid, sulphureted hydrogen, carbonic acid, and water, are supplied, by the air in a great measure, for the growth of plants, but they are not absorbed directly from the air, and hence by the leaves, which are analogous in function to the lungs and kidneys of an animal, as was formerly supposed, but by the roots from the ground.

These elements of serial supply, must first, before being absorbed into the plant, come in contact with its roots, which they do by being dissolved in the water of rains, and thus carried into the earth. Some, it is true, as carbonic acid, may originate in the earth from the decomposition of vegetables or minerals, but, wherever found, being heavier than air, it falls to the ground, and soaks into the earth, if properly porous, very readily, or it is carried in and mingled with water, by the rains, and thus the plant is reached from the air, first through the earth, by these materials.

It is a general law of plants that, during the day-time, they exhale or give out oxygen gas, and at night exhale carbonic acid gas. In consequence of this fact, it has been assumed that the plant inhaled or absorbed all its carbonic acid gas through the *stoma* (*a a a a*, Fig. 19), or mouths of the leaf during the day-time, from the atmosphere and oxygen during the night. But this doctrine unfortunately is surrounded by too many difficulties and improbabilities. The atmosphere contains, according to the advocates of the "*breathing*" theory, about 1.3000 of its quantity of carbonic acid gas; yet they as dogmatically assert that if the air contained 1.1000 part of its quantity of this gas, all animated nature would cease to exist. These statements are possibly correct, but then these same theorists assert that a bushel of charcoal produces 2500 gallons of carbonic acid gas,—that each adult person exhales about 140 gallons of this gas daily, and that about four per cent of all oxygen inspired is converted into carbonic acid gas. Now, supposing the atmosphere to be five miles high,

Digitized by Google

and all the sources of the production of carbonic acid gas estimated very moderately indeed, it will be found that sufficient carbonic acid gas is produced all the year round to keep the atmosphere in a very deleterious, if not absolutely fatal, condition, while vegetation or growth of plants does not continue more than three or four months.

From this statement the following inference is perfectly legitimate: Plants do not receive *all* their carbon through the leaves; but obtain much of it from the soil. Limestone contains 44 per cent. of its weight of carbon. (*Youmans.*) The Plant does not inspire or absorb carbon during the day, then cease at night and inspire oxygen, while it at night expires or gives out carbonic acid gas. It absorbs its gases from the soil; the sunlight changes and fixes the carbonic acid as a portion of the body, or part of the plant, while the oxygen escapes; at night the sun-rays no longer act as an exciting cause to arrest and consummate the fixation of carbon, and consequently both the carbon and oxygen escape together during the night; but the first rays of the morning's sun again arrest the carbon, while the oxygen only escapes.

Wheat is an endogenous plant, that is, one in which the materials of growth are not deposited as in an oak tree, in successive rings upon the outside, but the deposit is made in the center of the axis of growth, and the bulk of the plant is made up of the cells here formed, deposited, changed in place, toward the outside, and in character to agree with the object to be obtained.

Arising from the center or axis of growth, then, corresponding with the root or base of the perfect leaf, each new leaf and joint of the stem grows upward rapidly after the spring is sufficiently advanced to afford heat and regular moisture. But if sown on a stiff clay, and the spring should be very dry, the soil will *bake* and crack apart, as at *a*, *e*, and *b*, *e*, Fig. 17, and where the roots are thus severed, the plant necessarily dies. Every succeeding joint and corresponding leaf is protected by those preceding, which form an involucre for

Digitized by Google

it, until when the head begins its growth it is surrounded and protected by a number of leaves and leaf stems, which always surround their proper joint, and the shaft or stalk arising from it, for some distance upward. Within this involucre of leaves the head is formed, first by the deposition of materials to form the different parts of fructification, the glumes, or bracts, the stamens and pistils, and then the bran of the seed and the seed contents, successively. At first these parts are quite indistinct, being formed of delicate cells, deposited somewhat in the form of scales, but as growth proceeds they soon become distinct,—the glumes or chaff inclose the organs of fructification, consisting of the ovary, style, and stigma, which are the female organs of generation collectively designated as the pistil, and the stamen or male organ divided for description into filament, and anther, the latter of which is the essential organ, and at a proper time splits and emits a powder called pollen, which is the fructifying principle of plants.

After the ovary is fully impregnated, then the deposit of the materials forming the body of the grain begins, and when completed the watery portions, which existed in the state known as "*in the milk*," because the starch is suspended in a milky solution, are then gradually absorbed, the grain ripens, dries, and is then fit for preservation or reproduction.

Should, however, from any cause, the impregnation be prevented, then will the head be sterile, or the glumes will be filled with a black mass of powdery matter. In some cases ergot is produced. Some writers assert that when the impregnation fails *smut* is invariably produced. From the period of impregnation until the ripening of the berry, are many steps and liable to be interrupted by many causes, by which the incalculably important product, wheat, arrives at perfection, and notwithstanding the many dangers to which it is exposed, nature has so wisely fortified herself against these as to secure the continuance of this plant in spite of them all. Thus are all creatures directly and indirectly guarded, and the species almost certainly preserved.

Digitized by Google

CHAPTER XII.

BOTANICAL DESCRIPTION OF THE WHEAT PLANT.

In the preceding chapters reference was frequently made to certain portions of the wheat plant, which, from the terms employed, may not have been obvious to the non-scientific reader. A brief description of the various portions of the plant will therefore not be irrelevant.

In botanical language the *head* of wheat is called a *spike;* a head of oats is called a *panicle;* the pyramidal form of flowers like that of the Lilac, is called a *thyrse;* a bunch of currants, or wild cherries are called a *raceme;* the hawthorn bears fruit in the form of a *corymb;* the parsnip, caraway, etc., in the form of an *umbel;* elder, dogwood, etc., in the form of a *cyme;* the Indian turnip and skunk cabbage in the form of a *spadix;* while the flowers of walnut, hickory, oak, birch, etc., are borne on *catkins* or *aments.*

That which we in common language call a *breast* of wheat, is by botanists called a *spikelet.* That which farmers call *bearded* wheat, botanists call *awned* wheat. The *spikelets* (whether awned or not) are generally three, although sometimes five flowered. *A* (Fig. 20) represents a three flowered spikelet, and *E* (Fig. 21) a five flowered one; but in almost all the five flowered varieties, two flowers (4 and 5) are sterile or barren, and in the three flowered ones the central flower (10) is barren. The spikelets are placed on alternate sides of the *rachis* (1, Fig. 20), so that the edges of the florets (5, 5, 10, Fig. 20) are toward the rachis. The rachis or shaft is jointed, and the spaces between the joints are termed the *internodii*—the spikelets rising one above another on each side of the rachis constitute the *spike*, ear, or head.

The glumes (*A* 4 4, or *E* * *) are transverse,—that is, they are right and left—they are nearly equal and opposite, herba-

Digitized by Google

ceous and nerved, or have small nerve-like ribs. They are, in other words, the two lowermost *chaff* of each spikelet, and

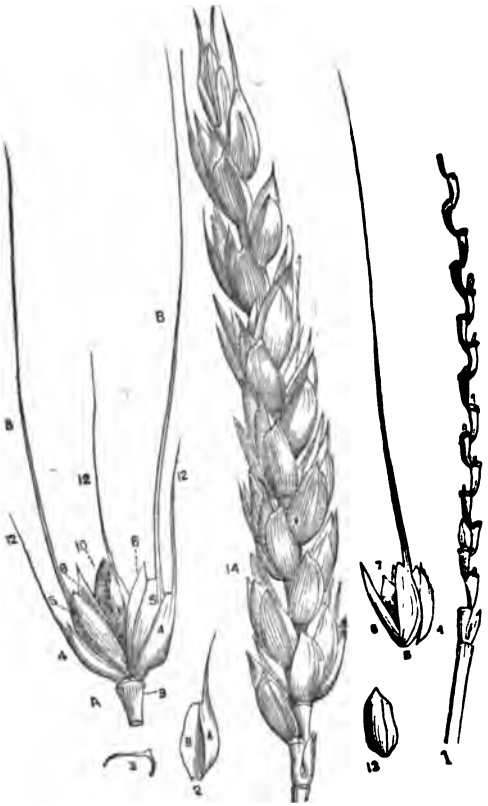


FIG. 20.

correspond to the calyx of non-gramineous plants, while each of the florets or palæ (*A* 5, 6, *B A* of 2) serves the purpose of a corolla or flower cup. The outer palæ in bearded wheat is awned as at *A* 5; but in bald or smooth wheat the awns are wanting, as at *A* in No. 2, or the head of wheat in Fig. 20, or the breast *e* of Fig. 21.

Digitized by Google

The awns or beards are apparently smooth when passed through the fingers, the chaff end foremost, which are found to be exceedingly rough when passed through with the point foremost. *g* (Fig. 21) represents a section of an awn magnified eight diameters; from this it will be seen that it is well garnished with teeth or a saw-like edge. The shape of the chestnut is entirely dependent upon the place which it occupies in the hull, and it has one or two flat sides according to the place in which it grew—if in the center of the "*burr*," it has two flat sides, or in case the two end ones were not impregnated, it is round; but if it grew in either end then it invariably has one convex and one plane or flat side. So with wheat; the grain in the center of the spikelet or breast is *always* "plumper" than the ones on either side of it; thus *f* (Fig. 21) represents the comparative size and shape of the grains in a three grained breast—the upper three figures showing consecutively the right-hand, central, and left-hand berries, with their embryos, while *f* represents the reverse side of the central grain.

FIG. 21.

Some certain florets in each variety of wheat in general are fertile, while others are uniformly barren, and the aggregate inflorescence of the several varieties differ widely in the length and form of the rachis, the size, shape, and packing of the spike—the comparative length of the glumes, the number and fertility of the florets, and above all in the various properties and colors of the seeds.

FIG. 22.

Fig. 22 represents a spikelet in bloom—with the anthers fully extended. The glumes (4) are generally about twice as long as they are wide, and are traversed by a mid-rib or nerve, appearing like a

Digitized by Google

raised line on the under side of the glume. No. 3 of Fig. 20, is the profile of a glume. There is generally a smaller nerve or rib on each side of the mid-rib, more strongly marked at the base than at the apex of the glume. The tooth-like projection which we perceive more or less developed on the upper glumes of the blossom—these glumes are also more properly called palæ—as at 6 of *A*, Fig. 20, are the indications only of an awn, which in wheat is wanting, yet is more or less fully developed in rye and barley. The glumes 5, 6, or *A*, *B*, of No. 2, are termed the inferior and superior palæ, exterior or interior palæ, or lower and upper palæ, while 4 is termed the glume of the calyx. The exterior *A* of No. 2 palæ generally partakes of the same shape of the glume of the calyx, but is rather longer; the interior one (*B*), on the contrary, is cuticular, awnless, and two-nerved. Both of these nerves are prominent, and the cuticular part between them is folded simply to correspond with the cavity of the exterior glume, and is bent inward.

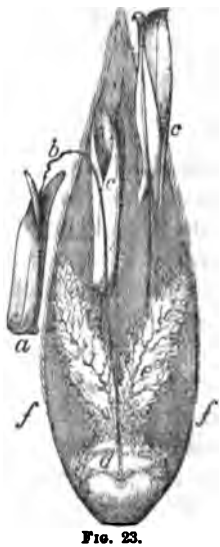


FIG. 23.

Between the glume *A*, *B*, No. 2, or 5, 6 of *A*, Fig. 20, are found the three anthers, *a*, *c c*, Fig. 23, and the two feathery portions of the pistil *e*. The pistil is the female portion of the flower, and is situated on the top of the *ovule* or young seed-grain *d*. These portions, namely, the pistils and stamens, constitute the flower or blossom of the wheat. The stamens consist of two parts—the filaments *b b b*, and the anthers *a*, *c c*. The filaments connect the anthers to the exterior of the ovule. The anthers contain the pollen grains, which contains the male fecundating fluid, principle or property. The color of anthers is a bright yellow, so also is that of the pollen grains themselves; these grains are so small as to

Digitized by Google

be called "*dust*," and are not, perhaps, more than the one-ten-thousandth part of an inch in diameter. Fig. 24, on this page, represents a portion of an anther highly magnified and divided transversely, showing the abundance and arrangement of the pollen grains.

When the pollen grains are mature, the anthers protrude between the palæ *A*, *B*, No. 2, but become ruptured at the end attached to the filament before being entirely extruded, so as to shed the pollen on the pistil *e*, before they leave the inner portion of the glume. No pollen which may be shed on the *outside* of the glume, is of any service in fecundating the ovule, because the palæ *A*, *B*, No. 2, are so closely in contact that no pollen could, by any adventitious circumstances, find its way between them to the pistil.

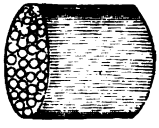


FIG. 24.

The pollen grain consists of an exceedingly thin pellicle or skin, enveloping a mass of transparent adhesive fluid. Whether this fluid performs a function in the vegetable kingdom, similar to that performed in the animal kingdom by the seminal fluid, is not fully established, but that it is indispensable in perfect fecundation is incontestably established. Many physiologists, however, are of opinion that the plant in the process of hybridization, whose ovule is impregnated by the pollen of another plant, becomes the father, while the one that furnished the pollen leaves the impress or characteristics of the mother on the hybrid. So long as this point remains unsettled, horticulturists can not labor as intelligently in their profession as they can when the proper function of the pollen shall have become fully known.

When the pollen is shed from the anther it falls upon the feathery portion of the pistil, *e*, Fig. 23, where it is retained by an adhesive fluid with which the entire pistil is overspread. Fig. 25 represents a portion of the pistil highly magnified; *a c* are ducts or passages leading to the ovule. The pollen grains are by some inherent power attached to the orifice of one of

Digitized by Google

these ducts, as at *d*; finding the duct too small to admit of the passage of the grain in its globular form, the grain assumes an elongated form—being sometimes ten times the diameter in length. When it arrives at the termination of the duct the pellicle or envelop dissolves and the fluid mingles with a similarly appearing fluid in the ovule. As soon as the pistil and stamens have performed their reproductive function they wither and decay and can not be made to perform the function anew.

Fig. 25.

Although it may be somewhat irrelevant in this place to contradict a very generally received opinion, yet as every reader will have the description and statement of the functions of the different parts of the blossom fresh on his mind he will at once see the absurdity of the general opinion alluded to, namely: When wheat is in full bloom and is subjected to a heavy rain it is said that the rain knocks the bloom off and the spikelets are sterile in consequence. The truth is that no part of the blossom is at any time exposed other than the anthers, and as they have already shed their pollen on the pistil before they were extruded, and as the sides of the palæ (A B. No. 2) which contain the young seed are in close contact so that no water can penetrate except that which finds its way through the body of the palæ itself, it can not be that the loss of the anthers by the rain is the cause of sterility.

There are properly speaking two suites or kinds of root belonging to the wheat plant. Those which spring from the seed itself when sowed are termed *seminal* or seed roots. These serve to elaborate nutriment for the plant until it has grown high enough to form a crown, joint or knot, just beneath the surface of the soil, as *a* (Fig. 14) in the annexed figure. As soon as this joint is formed the plant commences to *tiller* or *stool*, that is, it sends out a new suite of roots, and an additional number of stems. When the roots at *a* are suffi-

Digitized by Google

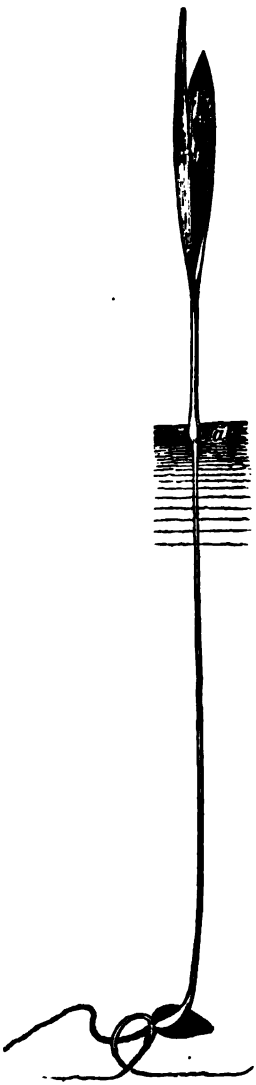


Fig. 14.

ciently developed to furnish the parent and young plants with the requisite kind and amount of nutriment, then the original or seminal roots are absorbed and disappear. This *fact* is denied by Mr. D. J. Browne of the Agricultural Department of the Patent Office in his report for 1857, but we can not conceive how we possibly can be mistaken in our observations, because we have examined the plant sown at all depths from one to seven inches, and have never found any tillers at a greater depth than from one-half to three-fourths of an inch from the surface, although we have found seminal roots at the depth of five inches on the same plant which tillered at the depth of half an inch. This was uniformly the case in all our observations; we were not led to expect to find tillers at any point except at the seminal roots, and to us at least the fact was new that the plant threw out two sets of roots; and for this reason we made extensive observations, because at first we supposed the coronal roots to be adventitious or accidental, and not the uniform law which we found it to be. In the spring time or even late in the fall when the plant has tillered, it presents the appearance represented in Fig. 15—that is the multiplied stalks proceed from roots in no case exceeding an inch from the surface of the soil. The seminal

Digitized by Google

roots entirely disappear after tillering has fairly commenced, and we are certain that the plant does at no time after tillers have been formed depend upon the seminal roots for existence. If it did, how will Mr. Brown explain the fact that not unfrequently are the seminal roots severed by upheaval caused by frost in winter? Or how will he explain the following fact if the life of the plant depends on the seminal roots?:

FIG. 15.

In the "Philosophical Transactions" it is recorded that Mr. C. Miller, of Cambridge, the son of the eminent Horticulturist, sowed, on the 2d of June, a few grains of common red wheat, one of the plants from which had tillered so much, that on the 8th of August he was enabled to divide it into eighteen plants, all of which were placed separately in the ground. In the course of September and October so many had again multiplied their stalks, that the number of plants which were separately set out to stand the winter was sixty-seven. With the first growth of the spring the tillering again went forward, so that at the

Digitized by Google

end of March and beginning of April, a farther division was made, and the number of plants now amounted to 500. Mr. Miller expressed his opinion that before the season had too far advanced one other division might have been effected, when the number might have been at least quadrupled. The 500 plants proved extremely vigorous, much more so than wheat under ordinary culture, so that the number of ears submitted to the sickle was 21,109, or more than forty to each of the divided plants; in some instances there were one hundred ears upon one plant. The ears were remarkably fine, some being six or seven inches long and containing from sixty to seventy grains. The wheat, when separated from the straw, weighed forty-seven pounds and seven ounces, and measured three pecks and three quarters, the estimated number of grains being 576,840. Such an enormous increase is not of course attainable on any great scale, or by the common modes of culture; but the experiment is of use as showing the vast power of increase with which the most valuable of vegetables is endowed, and which by judiciously varying the mode of tillage may possibly in time be brought into beneficial action.

The divisions above referred to must have been made from the coronal roots—they could not possibly have been made from the seminal roots; because the seminal roots produce *one* stalk only—that the new stalks proceed from the coronal roots only must be evident to every one who has ever made any examination of the subject. The seminal roots in short can no more produce two or half a dozen stalks *direct* from themselves, than two or half a dozen cows can produce one calf and each one have an equal share in the maternity.

A writer in the (British) Farmer's Magazine insists that the tillers proceed from the seminal roots entirely, and says of the coronal roots that "so far from being an essential appendage to the plant are entirely accidental in their formation!" But in the course of his article he says "the establishment of this fact (that the plant is nourished entirely by the seminal roots) greatly strengthens the argument in favor of deep

Digitized by Google

sowing, by which the chance of the formation of a joint below the surface is rendered more certain, which also insures the formation of coronal roots." *Query.*—If the coronal roots are "accidental" and subserve no purpose in elaborating nutriment for the plant, *why is it desirable to produce them?*

Nature makes no mistakes; and has in the wheat plant provided the coronal roots as a means of multiplying the plant, in order that the grains may be produced in the greater abundance. Fig. 18 represents the tillers of a mature stalk and I will venture the assertion without fear of successful contradiction that no one ever found such a union of stalks at a depth of five or six inches from the surface of the ground during the life-time of the plant—neither have any roots ever been found above the place from whence these united stalks proceed.

FIG. 18.

Digitized by Google

CHAPTER XIII.

WHEAT REGIONS OF THE WORLD.

NOTWITHSTANDING cereals other than wheat are in general use as a staple article of food among the laboring classes in Europe, Asia and South America, yet considerable wheat is grown in all these countries. Wheat is extensively grown in New South Wales; at the Cape of Good Hope, is grown to some extent in the African Barbary States and Egypt, in Asia Minor, in Europe generally, in Arabia, Persia, etc. It is also grown in Chili, La Plata, New Grenada, Ecuador, and other South American States.

Summer and winter varieties are grown in almost all these regions; but both the polar and equatorial limits necessarily differ somewhat, although this difference is not definitely ascertained, because travelers, and even botanists, very seldom allude to the distinction. In Scotland wheat is cultivated north of Inverness in Latitude 58°, in Norway, at Drontheim, latitude 64°, in Sweden to latitude 62°, in Western Russia in the environs of St. Petersburg to latitude 60° 15′, while the polar limits in Central Russia are at 59°. Wheat is here almost an exclusive cultivation, especially in a zone which is limited between the latitude of Tchernigov, latitude 51°, and Ecatherinoslav, in latitude 48°.

In central and western Europe wheat is cultivated chiefly in the zone between latitude 36° and 50°; further north *rye* is generally preferred. South of this zone, new combinations of heat, with humidity and the addition of many other cultures, very sensibly diminish the importance of the wheat crop.

In Chili and the United States of Rio de la Plata, the cultivation of wheat is very productive. On the plateau of South-

Digitized by Google

ern Peru, Meyen saw most luxurious crops of wheat at a hight of 8,500 feet, and at the foot of the volcano of Arequipa at a hight of 10,600 feet. Near the Lake Titicaca, which is situated at an elevation of 12,846 feet, and where a climate of constant spring prevails, wheat very seldom ripens, in consequence of the coldness of the summer nights.

It is not known with any degree of certainty how far north on the American continent wheat may be grown. At Cumberland House, which is situated in latitude 54° N., long. 102° 20′ W., the officers of the Hudson's Bay Company have established a prosperous agriculture. Capt. Franklin found fields of barley, wheat, and even Indian corn, growing there, notwithstanding the extraordinary severity of the winter. The polar limits of the cultivation of wheat are the more important, since, during a part of their course, they coincide with the northern limits of those fruit trees which yield cider, and in some parts also with the limit of the oak, agriculture and forests both undergo a sudden and remarkable change of appearance on approaching the isothermal line, or line of equal summer temperature of 57° 2′.

The physical condition of the polar limits of wheat in countries where the cultivation has been carried to its utmost extent is as follows:

		Mean Temperature in Fahrenheit.		
Countries.	Latitude.	Year.	Winter.	Summer.
Scotland (Inverness)	58°	46°	35°	57°
Norway (Drontheim)	64°	40°	25°	59°
Sweden	62°	40°	25°	59°
West Russia (St. Petersburg)	60° 15′	38°	16°	61°

This table shows how little influence winter cold has in arresting the progress of agriculture toward the north; and this is confirmed in the interior of Russia, where Moscow is much within the limits of wheat, although its mean temperature is, according to Schouw, 53° 2′.

The isothermal curve of 57° 2′, which appears to be the minimum temperature requisite for the cultivation of wheat, passes, in North America, through the uninhabited regions of

Digitized by Google

Canada. The isothermal curve (or line of places having an equal winter temperature) of 68° or 69°, which appears to be the extreme limit of the possible cultivation of wheat, toward the equator oscillates between latitude 20° and 23°.

In Europe the cultivation of wheat is carried to a greater extent than in any other quarter of the globe. Annexed is a table showing the average product for a series of years in European countries. Of Russia and Turkey the amount exported only could be ascertained; but we are in possession of no facts by which the amount produced could be determined with any degree of certainty:—

WHEAT PRODUCED IN CONTINENTAL EUROPE.

Austrian Empire	27,735,568
British "	145,800,000
France	191,422,248
Russia (exported)	18,921,776
Belgium	13,849,160
Denmark	2,992,748
Holland	8,597,888
Portugal	5,499,280
Sardinia	19,975,000
Spain	46,914,800
Sweden and Norway	1,100,784
Turkey (exported)	4,628,720
Two Sicilies	64,000,000
Canada (North America)	60,470,184

The following table, compiled from authentic sources, exhibits the amount that Great Britain imported from other countries during a period of ten years, ending in 1852. From this table will be seen how very little wheat is imported from the United States by England; the *average amount*, as shown by the above table, is 5,154,245 bushels annually. This is less, by more than half a million of bushels, than one-fourth of the amount that Ohio annually produced, from 1850 to 1857, inclusive:—

Digitized by Google

WHEAT AND WHEAT FLOUR,

(Stated as Quarters of Wheat) Imported into Great Britain during each of the ten years ending with 1852, *exhibiting the quantity brought from each country.*

Countries.	1843. Quarters.	1844. Quarters.	1845. Quarters.	1846. Quarters.	1847. Quarters.	1848. Quarters.	1849. Quarters.	1850. Quarters.	1851. Quarters.	1852. Quarters.
Russia	33,.88	104,52.	36,781	204,8.0	850,587	523,138	599,556	638,613	699,.84	733,734
Sweden and Norway	678	10,782	679	218	8,647	5,344	6,494	35.	6	546
Denmark	69,8.4	94,499	74,170	61,5.3	73,5 .8	191,787	243,213	162,2.7	168,768	218,834
Prussia	659,503	551,015	424,539	360,881	492,928	528,15.	618,090	835,.60	690,17.	452,292
Germany, viz., Hanseatic towns, Oldenburg, Hanover and Mecklenburg	126,521	108,992	154,271	126,572	154,839	582,591	498,984	380,941	264,721	179,631
Holland	858	11,772	1,614	473	11,800	163,978	308,480	293,465	66,414	124,963
Belgium	332	1,101	983	3,0 .4	27,4 .9	178,398	3.6,099	201,992	69,046	25,961
France	3,131	44,875	35,809	73,774	179,250	320,010	742,023	1,145,14.	1,193,433	469,418
Spain	1	11	4,016	74,041	24,700	917	498	2,18.	11.	6,321
Italy	5,20.	80,280	57,403	194,25.	64,850	83,170	281,5.0	117,323	241,852	65,103
Malta	3,155	6,1.3	4,120	11,099	46,251	8,57.	9,049	10,59.	10,585	17,106
Greece	.....	.....	3,270	11,595	.....	4,129	61,13.	6,292	1.5	.....
Turkey, including Syria, Egypt, Wallachia and Moldavia	14,899	44,790	7.030	41,557	266,779	40,340	295,542	382,793	873,130	533,524
Cape of Good Hope	.....	83	2	87	2	2	1	.....	1	.....
British East Indies	3,.24	2,303	1,209	361	203	2,765	2,028	690	22	.....
Australian Settlements	1,232	4,210	14,035	20,34.	13,690	5,5.9	15,.99	14,584	104	.....
British N. American Colonies	113,44.	228.0 9	229,349	327,105	398,793	186,254	142,295	8.,39.	129,.8.	110,033
United States of America	26,000	8.,853	93,622	808,178	1,834,142	29.,102	617,131	5.7,.4.	9.1,8.	1,231,894
All other parts	2, 74	8	2,090	24,122	16,250	11,028	26,830	19,812	4, 5	5,272
Total	1,064,942	1,379,2 2	1,141,957	2,314,142	4,4 4,757	3,082,231	4,83.,.8.	4,8 0.2 :	5,. 0.2 .	4,1 4,892

Note.—The quarter consists of eight Bushels.

Digitized by Google

Wheat Trade of the Elbe, etc.—Next to Dantzic, Hamburg is, perhaps, the greatest grain market in the North of Europe, being a depot for large quantities of Baltic corn, and for the produce of the extensive countries traversed by the Elbe. The exports of wheat from Hamburg amounted, at an average of the eleven years ending with 1841, to 210,871 quarters a year. The price of wheat is frequently less in Hamburg than in Dantzic; but this lowness of price is altogether ascribable to the inferiority of the Holstein and Hanover wheats, which are generally met with in great abundance in Hamburg. Wheat from the upper Elbe, is of a better quality. Bohemian wheat is occasionally forwarded by the river to Hamburg; but the charges attending its conveyance from Prague amounts to full 15s. a quarter, and prevents its being sent down, except when the price is comparatively high. In 1841, the shipments of wheat from Hamburg amounted to 507,400 quarters, of which 460,900 were for England.

French Wheat Trade.—It appears from the account given by the Marquis Garnier, in the last edition of his translation of the *Wealth of Nations*, that the price of the *hectolitre* of wheat at the market of Paris, amounted, at an average of the nineteen years, beginning with 1801 and 1819, to 20 francs 53 cent., which is equal to 30 francs 80 cent. the septier; or, taking the exchange at 25 francs, to 45s. 6d the quarter. Count Chaptal, in his valuable work, *Sur l'Industre Françoise*, published in 1819, estimates the ordinary average price of wheat throughout France at 18 francs the hectolitre, or 42s. 10d. the quarter. The various expenses attending the importation of a quarter of French wheat into London, may be taken at a medium of 6s. the quarter. France, however, has very little surplus produce to dispose of; so that it would be impossible for her to export any considerable quantity without occasioning a great advance of price.

The mean of the different estimates framed by Vauban, Quesnay, Expilly, Lavoisier, and Arthur Young, gives 61,519,672 septiers, or 32,810,000 quarters, as the total average

Digitized by Google

growth of the different kinds of grain in France (Penchet Statistique Edementain). We, however, take occasion to observe that there can not be a doubt that this estimate was a great deal too low: and the more careful translations of the late French staticians fully confirm this remark.

The annual produce of the harvest of France was lately (1843) estimated, from returns obtained under official authority, at 69,558,000 hectolitres of wheat, and 112,958,000 ditto of other sorts of grain; making in all 182,517,000 hectolitres, or 62,740,000 imperial quarters. Of this quantity it is supposed that about sixteen per cent. is consumed as seed, nineteen per cent. in the feeding of different species of animals, and two per cent. in distilleries and breweries.

The foreign grain trade of France was regulated, till within these few years, by a law which forbade exportation, except when the home prices were below certain limits, and which restrained and absolutely forbade importation, except when they were above certain other limits. The prices regulating importations and exportations differed in the different districts into which the kingdom was divided. Latterly, however, importation has been at all times allowed under graduated duties, which, like those recently existing in England, become prohibitory when the prices sink to a certain level. The frontier departments are divided into four separate districts, the prices in each district governing the duties on importation into it, so that it sometimes happens that grain warehoused in a particular port, where it is not admissible except under a high duty, has been carried to another port in another district, and admitted at a low duty. An official announcement is issued on the last day of each month, of what the duties are to be in each district during the succeeding month.

Spanish Grain Trade.—The exportation of grain from Spain was formerly prohibited under the severest penalties. But in 1820, grain and flour were both allowed to be freely exported, and in 1823, this privilege was extended to all productions,

Digitized by Google

(*frutos*) the growth of the soil. There is now, in fact, no obstacle whatever, except the expense of carriage, to the conveyance of grain to the seaports, and to the foreigner.

Owing, however, to the grain-growing provinces being principally situated in the interior, and to the extreme badness of the roads, which renders carriage to the coast both expensive and difficult, the exports are comparatively trifling; this difficulty of carriage frequently gives rise to very great differences of prices at places in all parts of the country, only a few leagues distant.

Grain Trade of Odessa.—Odessa, on the Black Sea, is the only port in Southern Europe from which any considerable quantity of grain is exported. We believe, indeed, that the fertility of the soil in its vicinity, has been much exaggerated; but the wheat shipped at Odessa is principally brought from Volhynia and the Polish provinces to the south of Cracow, the supplies of which are susceptible of an indefinite increase. Owing to the cataracts in the Dnieper, and the Dniester having a great number of shallows, most part of the grain brought to Odessa comes by land-carriage. The carts with grain are often in parties of 150; the oxen are pastured during the night, and they take advantage of the period when the peasantry are not occupied with the harvest, so that the charge, on account of conveyance, is comparatively trifling.

Both soft and hard wheat are exported from Odessa; but the former, which is by far the most abundant, is only brought to England. Supposing British wheat to sell at about 60s., Odessa wheat in good order would not be worth more than 52s. in the London market; but it is a curious fact, that in the Mediterranean the estimation in which they are held is quite the reverse; at Malta, Marseilles, Leghorn, etc., Odessa wheat fetches a decidedly higher price than British wheat. The hard wheat brought from the Black Sea comes principally from Taganrog. It is a very fine species of grain; it is full ten per cent. heavier than British wheat, and has less than half the bran. It is used in Italy for making maccaroni,

Digitized by Google

vermicelli, and all things of that sort; little of it has found its way to England.

The voyage from Odessa to Britain is of uncertain duration, but generally very long. It is essential to the importation of wheat in good condition, that it should be made during the winter months. When the voyage is made in summer, unless the wheat is very superior, and be shipped in exceedingly good order, it is almost sure to heat, and has sometimes, indeed, been injured to such a degree as to require to be dug from the hold with pickaxes. Unless, therefore, means be devised for lessening the risk of damage during the voyage, there is little reason to think that Odessa wheat will ever be very largely imported into Britain. The entire expense of importing a quarter of wheat from Odessa to London, may be estimated at from 16s. to 18s. The exports of wheat from Odessa, and other ports on the Black Sea, to Constantinople, the Levant, Italy, the south of France, etc., have latterly been very large indeed. In 1846, the exports from Odessa only amounted to 1,276,502 quarters, and in 1847 to 2,016,692 ditto; the latter being, we believe, the largest exportation that ever took place in a single year from any single port Owing to the scarcity in England, about 400,000 quarters of the above quantity were shipped for that country, but the speculation entailed a heavy loss on the importer. The price free on board at Odessa considerably exceeded 40s. a quarter.

Encyclopedia Brittanica.

WHEAT REGION IN THE UNITED STATES.

A failure of the wheat crop in England affects the exchanges of the whole world; and a scarcity in France generally brings about a revolution.

In a country so extensive as ours, we need not fear a failure; but the boast so often made, that "we can feed the world from our surplus," is vain boasting. Beyond feeding our own great and constantly increasing population, we shall

Digitized by Google

not, generally, have any great surplus. We too often think that all our wild land is wheat land. This is far from being true. The land properly adapted to wheat, is limited to ten degrees of latitude, and twenty of longitude—embracing only about half of the States. Outside of this belt, wheat is raised, but it is generally a poor article of spring wheat, no better than northern rye.

To show that our wheat region is not capable of producing so great a surplus as we imagine, we have only to look at facts instead of fancies. We may take, perhaps, as the average crop of wheat produced, that of 1848—which was 126,000,000 bushels—and our population 22,000,000, which gives a trifle over five and a half bushels to each inhabitant. Now the consumption of wheat in England is 166,000,000 bushels annually, which gives six bushels to each inhabitant—about half a bushel more to each person than we should have if we consumed our whole crop. It is true we have a surplus that will average ten or twelve million bushels a year for export, but that is produced by the substitution of corn for wheat, as an article of bread. Cut off this substitute and we should be our own consumers of all our wheat and there would be a scarcity besides. As our exports have scarcely, if ever exceeded twelve million bushels, we may safely take that as the average surplus. Besides guarding against a partial failure of a crop of corn or wheat, we have also to look to the constant flow of population to our shores from abroad, as well as to the natural increase at home. The foreign tide setting to our shores may be put down at 400,000 annually: all of whom must be fed, for the first year at least. But it is estimated that our population will double in twenty-five years; and if our wheat-growing sections are fixed, and stationary in quantity, we must increase the ratio of wheat to the acre, or our surplus will, by the next census, be measured by the algebraic quantity of Minus.

The following tables of wheat grown in each State, were compiled from the census returns of 1840 and 1850:

Digitized by Google

	1840.	1850.
Alabama	838,52	294,044
Arkansas	105,878	199,639
California		17,228
Columbia, District of	12,147	17,870
Connecticut	87,009	41,992
Delaware	316,165	482,511
Florida	412	1,027
Georgia	1,801,830	1,088,534
Illinois	2,335,393	9,414,575
Indiana	4,049,375	6,214,854
Iowa	154,693	1,530,581
Kentucky	4,803,152	2,142,822
Louisiana	60	417
Maine	848,166	296,259
Maryland	8,345,788	4,494,680
Massachusetts	157,923	31,211
Michigan	2,157,108	4,925,889
Mississippi	196,626	137,990
Missouri	1,037,366	2,981,652
New Hampshire	422,124	185,658
New Jersey	774,203	1,601,190
New York	12,286,418	13,121,498
North Carolina	1,960,855	2,130,102
OHIO	16,571,661	*14,487,351
Pennsylvania	13,213,077	15,367,691
Rhode Island	3,098	49
South Carolina	968,354	1,066,277
Tennessee	4,569,692	1,619,386
Texas	000	41,929
Vermont	495,800	535,956
Virginia	10,109,716	11,212,615
Wisconsin	212,116	4,286,231
Minnesota		1,401
New Mexico		196,516
Oregon		211,943
Utah		107,702
Total	88,513,270	100,585,844

*Crop of 1849—the crop of 1850 was 28,769,139.

Digitized by Google

Our Agriculturists do not appear to be sufficiently aware of the facts—or at least manifest great indifference with respect to them if they are—namely: the limited area of wheat land and the necessity of properly managing it so as to produce the greatest possible amount of wheat with the least possible exhaustion of the soil—let us examine the different sections of our country, and see the extent of those adapted to the raising of wheat.

The State governments of New England have, by the offer of premiums, encouraged their farmers in the production of wheat; but though much labor may produce small crops, we believe all will agree that New England is not, and can not be, a wheat-producing section. The States south of North Carolina, or say latitude 33°, never have, and never will be wheat-growing States. Kentucky, Tennessee, and Missouri are best adapted to corn, and wheat can never be regarded as the great staple of either. Cotton is the staple of Tennessee; hemp and tobacco of Kentucky and Missouri. Kentucky and Missouri, too, are unsurpassed as grazing sections, and for raising stock; and there is no reason to suppose that they will change the agriculture best suited to their condition, for wheat culture.

Indiana, Illinois, and "The Far West," are painted to us as the great wheat regions, to which we are to look for the wheat to supply the world. The common idea is, that this whole region is peculiarly adapted to wheat; but this, like many other popular theories, may not be strictly correct.

The prairie sod—the virgin soil of the West—when first broken up, generally produces good wheat. So it will be in New England. But virgin soil will not always last—like virgin beauty it becomes old and fades with age. The prairie sod consists of friable mold, and when, by cultivation, and exposure to the atmosphere, it becomes completely pulverized, and then covered with surface water, as much of it frequently is, the frost will heave the wheat out of the ground, and it is winter-killed. If the plants are so fortunate as to escape

Digitized by Google

winter-killing, this friable mold, when dry, is an almost impalpable powder, and the high prairie winds will blow it from the roots of the plants, exposing them to the dry and parching rays of the sun, and what the winter has spared the summer kills. These effects will not always follow, but the older these prairie lands become the more subject will they be to them.

It is a melancholy truth, and one that reflects much on the skill and foresight of American farmers, that, while the wheat crop of England has increased at least fifty per cent. in the last century, that of the United States has fallen off in nearly the same proportion. A century ago, New England, Delaware, and Virginia raised wheat as an ordinary crop; now a wheat-field is a rarity in these States, and they may be considered as no longer wheat-producing regions. Portions of New York, that formerly produced thirty bushels to the acre, now seldom average over eight bushels; and Ohio, new as she is, with her virgin soil, does not average over thirteen bushels to the acre.

If we go on as we have for the past century, from bad to worse in our tillage, the lands in Ohio, in half a century from this time, will not produce wheat enough to supply our own wants. It is less than that time since Vermont was a large wheat-exporting State; now she does not export a bushel, but imports at least two-thirds of all the flour consumed in that State. Instead of increasing the productiveness of our wheat land, as is done in England, our wheat region is diminished more than one-half, and the productive quality of what is still used has diminished in equal proportion.

This is a practical, matter-of-fact view of the case, and one that addresses itself seriously to the common sense of the farmer and national economist.

To look at facts: Illinois, high as she stands in reputation, as a wheat-growing State, is behind cotton-growing Tennessee, and hemp and tobacco-growing Kentucky, in the production of wheat. Illinois produces less than seven bushels of wheat to each inhabitant, while Tennessee produces nine bushels,

Digitized by Google

and Kentucky produces seven bushels and a half to each inhabitant.

Illinois no doubt feels highly flattered at the account of the fertility of her soil as stated by James Caird, a member of the British Parliament, who journeyed through that State in the autumn of 1858, and published a work (in May, 1859) on "PRAIRIE FARMING IN THE WEST." In that work he says of Illinois:

"The characteristic soil of this State is that of the prairies, of which it chiefly consists, and to which alone my attention was directed. They comprise many million acres of land, more or less undulating—in their natural state covered with grass, which is green and succulent in May, June, and July, shoots up in autumn from three to six feet in hight.

"How the prairie formation originated it is unnecessary here to inquire. It is sufficient to know that we have a soil evidently of great natural fertility, which, for thousands of years, has been bearing annual crops of grass, the ashes or decayed stems of which have been all that time adding to the original fertility of the soil. So long back as we have any knowledge of the country, it had been the custom of the Indians to set fire to the prairie grass in autumn, after frost set in, the fire spreading with wonderful rapidity, covering vast districts of country, and filling the atmosphere for weeks with smoke. In the course of ages a soil, somewhat resembling an ash-heap, must have been thus gradually created, and it is no wonder that it should be declared to be inexhaustible in fertility. In Europe such tracts of fertile country as the plain of Lombardy, are known to have yielded crops for more than two thousand years without intermission, and yet no one says that the soil is exhausted. Here we have a tract naturally as rich, and with the addition of its own crops rotting upon its surface, and adding to its stores of fertility all that time. It need occasion no surprise, therefore, to be told of twenty or thirty crops of Indian corn being taken in succession from

Digitized by Google

the same land, without manure, every crop, good or better, according to the nature of the season.

"Externally the prairie soil appears to be a rich black mold with sufficient sand to render it friable, the surface varying in depth from twelve inches to several feet, lying on a rich but not stiff yellow subsoil, below which there is generally blue clay. This drift surface lies on rocks consisting of shales, sandstones, and limestones, belonging to the coal measures.

"Its chemical composition has been ascertained for me by Prof. Voelcker, consulting chemist to the Royal Agricultural Society of England, to whom I sent four samples of prairie soil for analysis, brought by me from different and distant points of the lands belonging to the Illinois Central Railway Company. They bear out completely the high character for fertility which practice and experience had already proved these soils to possess. The most noticeable feature in the analysis, as it appears to me, is the very large quantity of the nitrogen which each of the soils contains, nearly twice as much as the most fertile soils of Britain. In each case, taking the soil at an average depth of ten inches, an acre of these prairies will contain upward of three tons of nitrogen, and as a heavy crop of wheat with its straw contains about fifty-two pounds of nitrogen, there is thus a natural store of ammonia in this soil sufficient for more than a hundred wheat crops. In Dr. Voelcker's words, 'it is the largest amount of nitrogen, and the beautiful state of division, that impart a peculiar character to these soils, and distinguish them so favorably. They are soils upon which I imagine flax could be grown in perfection, supposing the climate to be otherwise favorable. *I have never before analysed soils which contained so much nitrogen, nor do I find any soils richer in nitrogen than these.*'"

If the nitrogen doctrine were the correct one—that is, that nitrogen in the soil is the only indispensable element to insure abundant crops of wheat, then we should expect these prairie soils to be the most prolific ones in the world. But there are

Digitized by Google

other elements as well as nitrogen indispensably necessary, of which more mention in detail will be made in a subsequent chapter.

To avoid the evils of winter-killing in the culture of wheat, in Illinois, they have resorted to the culture of spring wheat, sown on the land where the fall-sowed crop had been winter-killed. This increases the quantity at the expense of the quality, for every one who has observed the quotations of wheat in New York, must have observed the depreciation in Illino s wheat. Even the spring wheat, as such, is of an indifferent quality. But the honorable member of Parliament himself is of opinion that these prairie soils are not adapted to wheat, although "*rich in nitrogen.*" He says, in continuation:

"Though these soils are so rich in nitrogen, they seem to be too loose for wheat, which is undoubtedly a precarious crop upon them. The open prairie country is so wind-swept in winter that the snow seldom lies long to any depth, and the young wheat is thus left unprotected to the frost. Should it escape that, it is liable to be thrown out by the rapid changes of weather in spring—and if it is fortunate enough to escape both, it is sometimes destroyed, as it was last year, by its enormously rapid growth in forcing summer weather, growing, as it does, almost on a muck heap. In such a season as the last, the prairie wheat crops of Illinois were injured precisely in the same manner as our own in this country sometimes suffer from a too heavy dose of guano, in a warm, moist summer. The growth is too rapid, the vesicles of the stem burst, and the ear does not fill. I can not doubt that Prof. Voelcker indicates the proper remedy for this in the application of lime, in which these soils are comparatively deficient. It would consolidate the soil, render the wheat less liable to be hoven, and help to strengthen the straw, and render the growth less rank. There is abundance of lime in the country, so that the remedy is at hand, and will undoubtedly be applied under a more scientific system of agriculture.

Digitized by Google

"Autumn wheat is the most valuable corn, but it is also the most difficult to be grown, for it has to withstand the unprotected severity of the winter. The earlier it is sown after the 1st of September, the more likely is it to succeed, and it is generally successful when sown on the first and second crops of a newly-plowed prairie which had been broken in proper season. If any of it should have been destroyed by frost, the ground is sown in spring with spring wheat, and this seldom fails.

"The geological survey of Iowa and Wisconsin, carried on by order of Congress, gives the reasons why those Western States can not be permanently first-rate wheat lands. The report states that 'a striking feature in the Iowa and Wisconsin soils (and the same remark applies to the Illinois prairies) is the entire absence, in most specimens, of clay, and the large proportion of silex.'"

Now silex, or sand, and calcareous earth, and humus, are necessary for wheat; but it also requires a considerable mixture of clay.

An agricultural writer, the late Mr. Coleman, states that "*The soil preferred for wheat, in England, is a strong soil, with a large proportion of clay.*" The absence of this clay is what renders the prairie soil so friable, and is the great desideratum in the soil to make it a permanently productive wheat soil.

Henry L. Ellsworth, of Indiana, an extensive farmer, and able agricultural writer, says: "After a full consideration of the subject, I am satisfied that stock raising, *at the West*, is much more profitable than raising grain. The profits of wheat appear well in expectation, on paper, but the prospect is blasted by a severe winter—appearance of insects—bad weather in harvesting, in threshing, or transporting to market—or, last, a fluctuation in the market itself."

Solon Robinson, a prominent agricultural writer, says: "In southern Indiana, Illinois, all of Kentucky, Tennessee, and northern Missouri, it [wheat] is affected by the rust. It is

Digitized by Google

the most precarious crop in the West, and altogether unsafe for the farmer to rely on."

These parts form the belt of ten degrees of latitude, and twenty degrees of longitude, as the wheat-growing section of the United States. Much of this section, even, is now, by continued cropping, exhausted and unproductive. Maryland, Virginia, and Delaware, are worn out, and although naturally adapted to wheat growing, must remain unproductive until restored by nature, or a kind of culture different from that furnished by slave labor.

The natural, and permanent wheat region, lies between latitude 33° and 43° North. Wheat can be produced North and South of this belt, but cotton, sugar, and tobacco will ever be more profitable South,—and even a part of the territory within these bounds is better adapted to cotton, tobacco, and hemp, than it is to wheat. A part of it is exhausted; and a part of it, for want of clay in the soil, will, by cultivation, become friable—a black mud that will freeze out the plants in winter, and an impalpable dust that will blow away and leave the roots bare in the summer.

This wheat section embraces Ohio, the south parts of Michigan and New York, the whole of Pennsylvania, Maryland, Virginia, and Delaware; and in these States we find where is raised, or has been, the greatest wheat production. Ohio stands at the head of all the wheat-growing States, in the aggregate of her production. Her crop in 1850, was twenty-eight million bushels, being nearly sixteen and a half bushels to each inhabitant. The geological survey of the State gives the reason, and confirms the statement, that "*a large mixture of clay in the soil is necessary to the perfect growth of wheat*," and that the absence of it, from the soil of the prairies of the West, would prevent them from ever becoming permanently good wheat-producing sections.

Thus, the reports of the geological survey of Ohio shows the soil to be "clayey," "clayey loam," and "clay sub-soil," and it produces sixteen and a half bushels to each inhabitant,

Digitized by Google

while Indiana, with a richer soil, produces only eight and a half bushels, and Illinois, with a still richer soil, produces only seven bushels to each inhabitant. Virginia, Maryland, and Delaware, as well as New York, were formerly great wheat-producing sections. But many parts of New York, that formerly produced twenty-five bushels to the acre, do not now average over five bushels; and many parts of Maryland, Virginia, and Delaware, that formerly produced abundantly, will not now pay the cost of cultivation. EXHAUSTION is written all over them, in language too plain to be misunderstood.

Ohio has reached her maximum of wheat production, and, if not retrograding, is at least stationary. Thirteen bushels to the acre, may be set down as an average production, and this average must continue to grow rapidly less, till, like the exhausted lands of Virginia, her soil will not produce enough to support the cultivator, unless an improved system of husbandry is introduced to increase its fertility. One great source of deterioration in exhausting our soils, has been in the manufacture of potash, and the export of it to foreign countries, or to our manufactories. In this way our soil has been robbed of an ingredient, without which no plant can mature, and no cereal grain form. As our forests have disappeared, this source of deterioration must be cut off, but a serious injury has been inflicted, which nothing can cure but the re-furnishing of the potash to the soil. How it can be done, is the great inquiry for our farmers.

The export of our flour has been another source of exhaustion to the soil, in taking away from it the phosphate of lime that is necessary to give plumpness to the kernel.

This exhaustion can be more easily remedied by the application of bone dust. For many years the English farmers have carried on a large traffic in old bones, paying five dollars a ton for them. This has stimulated many to gather them up, and even rob the battle-fields of Europe of the bones of their brave defenders, to enrich the wheat fields of England. By this course, the fields of England have been made more

Digitized by Google

productive, while the countries from which the bones are taken have been permanently injured by their loss.

The English, too, have sent to every island of South America to procure *nitre*, in the form of guano, to fertilize their fields, while the Americans not only import little or none, but negligently waste that which nature forces on them.

The idea of skinning the soil of our wheat-growing sections, with a view of abandoning them soon and going west to procure new and fertile wheat land, must itself be abandoned, as we are on the western verge of the permanently good wheat producing section.

Our only resource now is to preserve our wheat lands where they are not exhausted, and to restore them where they are. Under judicious and scientific tillage, the lands of England, that have been under cultivation for hundreds of years, now produce twenty-five bushels to the acre. This is done by a liberal use of lime, plaster, clover, and a judicious rotation of crops. In wheat-raising, this rotation is clover and corn. Peas, beans, turnips, beets, and carrots, all furnish a good rotation, and furnish good food for sheep, which are good on wheat land. In fact the culture of wheat and raising of sheep should go together. The rotating crops furnish food for the sheep, and the sheep furnish the best of manure for wheat land. All the manure derived from the sheep should be carefully preserved for enriching their land. It is highly concentrated, and prepares the land for a generous crop of wheat at a small expense. The manuring agent consumes the crop that gives the land rest from wheat culture, and prepares the soil for another crop of wheat.

In order that the capacity of Ohio for wheat-growing, as well as other crops, may be more fully understood, the following table, exhibiting the entire amount of land owned by individuals in each county, as well as the quantity and quality of each description of land—that is, the amount of plow land, meadow land and forests in each county, have been compiled with great care and labor from authentic sources:—

Digitized by Google

COUNTIES. 1853.	Acres of Land.	Valuation of Land.	DESCRIPTION AND AMOUNT OF TAXABLE LANDS IN 1853. Arable or plow Land.	Meadow or pasture Land.	Uncultivated or wood Land.
			Acres.	Acres.	Acres.
Adams	288,466	$2,624,798	98,542	28,949	160,975
Allen	241,702	2,023,144	57,447	7,723	176,538
Ashland	267,319	4,159,982	136,319	26,134	104,866
Ashtabula	442,663	4,631,133	88,926	185,749	222,988
Athens	306,099	1,870,575	51,888	49,618	204,598
Auglaize	238,997	1,898,999	41,176	10,244	187,577
Belmont	333,013	7,166,284	142,195	54,964	135,854
Brown	311,354	4,947,102	105,183	46,452	159,819
Butler	292,191	10,782,939	154,985	36,535	100,671
Carroll	250,492	3,653,662	150,378	15,088	85,026
Champaign	270,029	6,104,644	102,761	55,125	112,148
Clark	248,668	5,457,477	101,546	48,342	98,780
Clermont	280,460	5,544,614	.....	.....	.....
Clinton	258,520	4,749,394	73,454	59,978	125,088
Columbiana	337,728	6,415,022	145,264	58,992	133,473
Coshocton	350,586	4,320,281	167,120	13,966	169,500
Crawford	253,304	4,041,481	126,234	12,536	114,535
Cuyahoga	279,399	9,927,903	39,375	125,592	114,371
Darke	371,053	4,211,858	97,721	22,469	250,863
Defiance	241,058	1,179,693	27,643	5,522	207,898
Delaware	283,925	4,108,632	76,058	51,179	156,688
Erie	156,388	3,997,976	58,674	45,799	56,915
Fairfield	317,407	7,654,679	171,827	19,808	125,772
Fayette	252,180	5,140,980	58,898	62,278	131,004
Franklin	334,383	10,130,934	113,963	56,213	164,207
Fulton	250,959	482,502	44,667	5,434	200,848
Gallia	276,312	1,834,777	64,033	30,686	181,592
Geauga	255,730	3,771,921	21,929	143,444	90,357
Greene	256,095	7,321,109	107,705	34,389	115,255
Guernsey	321,862	3,195,611	132,489	38,860	150,513
Hamilton	250,121	19,446,700	116,369	45,629	88,123
Hancock	333,595	3,239,681	77,366	24,265	231,964
Hardin	292,768	2,068,679	36,055	12,268	244,455
Harrison	253,858	4,418,617	100,143	59,817	93,898
Henry	208,133	.....	12,151	3,275	191,687
Highland	338,391	5,627,606	144,479	33,209	160,703
Hocking	247,546	1,697,503	71,069	13,506	162,971
Holmes	264,945	3,601,378	144,154	25,567	95,224
Huron	313,450	6,363,938	61,977	96,189	155,284
Jackson	235,102	.....	.....	.....	.....
Jefferson	257,117	4,487,038	130,208	19,933	106,976
Knox	390,058	5,274,320	145,786	39,570	131,729

Digitized by Google

COUNTIES. 1853.	Acres of Land.	Valuation of Land.	DESCRIPTION AND AMOUNT OF TAXABLE LANDS IN 1853. Arable or plow Land.	Meadow or pasture Land.	Uncultivated or wood Land.
			Acres.	Acres.	Acres.
Lake	144,687	8,086,138	88,002	60,940	50,745
Lawrence	289,916	.....	27,723	4,963	158,509
Licking	429,619	8,857,010	195,872	52,029	181,718
Logan	292,320	8,998,012	72,329	39,884	180,107
Lorain	305,828	4,941,555	84,347	129,342	142,139
Lucas	200,482	1,692,137	25,547	12,901	162,028
Madison	283,612	4,366,904	88,823	120,659	124,070
Mahoning	265,264	6,361,049	76,874	92,290	96,100
Marion	251,602	4,034,286	51,488	72,134	127,980
Medina	265,489	5,718,239	94,694	93,905	76,840
Meigs	260,416	2,128,169	61,473	9,403	189,540
Mercer	270,148	.....	.....	.....	.....
Miami	254,142	6,364,833	121,978	11,442	120,722
Monroe	284,976	2,329,345	119,166	9,236	166,574
Montgomery	286,713	9,620,178	162,172	20,485	104,056
Morgan	259,686	3,057,304	98,266	25,737	133,598
Morrow	251,517	3,979,957	93,185	40,135	118,197
Muskingum	419,134	8,177,234	214,920	14,610	189,604
Noble	254,926	2,377,206	78,285	51,816	124,875
Ottawa	155,642	960,929	8,623	2,767	144,247
Paulding	135,159	496,245	6,024	1,386	127,749
Perry	256,718	2,951,909	104,082	50,796	101,886
Pickaway	311,059	7.054,457	100,956	66,879	143,224
Pike	191,143	1,868,072	42,633	23.934	124,576
Portage	315,987	6,550,636	81.013	132,070	102,904
Preble	268,255	5,691.715	142,234	4,401	123,619
Putnam	244,544	1,178,617	26,119	10,103	208,322
Richland	312,724	4,870,029	148,593	38,958	125,173
Ross	392,896	6,972,811	153,016	51,941	187,939
Sandusky	255,399	2,181,382	62,848	29,500	163,051
Scioto	260,981	1,831,572	46,559	20,060	194,212
Seneca	344,817	5,413,939	144.940	28.233	171,644
Shelby	241,784	2,942,967	64,065	11,995	165,724
Stark	357,725	7,690,689	216,757	26,423	114,544
Summit	261,417	6.288,573	116,663	62,726	82,028
Trumbull	397,204	6,073,040	56,587	182,942	155,717
Tuscarawas	356,124	5,091,135	181,391	21,075	153,658
Union	269,471	2,800,985	89,938	44,422	185.111
Van Wert	233,291	1,032,488	19,219	3,285	1,858
Vinton	241,038	1,398,923	35,409	28,256	177,373
Warren	252,947	6,946,711	113,492	38.552	100,908
Washington	376,920	8,088,805	61,648	61,427	253,445

Digitized by Google

COUNTIES. 1853.	Acres of Land.	Valuation of Land.	DESCRIPTION AND AMOUNT OF TAXABLE LANDS IN 1853. Arable or plow Land.	Meadow or pasture Land.	Uncultivated or wood Land.
			Acres.	Acres.	Acres.
Wayne.....	343,089	6,018,145	169.785	22,030	151,274
Williams.....	260,228	1,072,204	62,555	1,220	196,452
Wood	347,086	1,957,675	34,686	8,734	302.001
Wyandotte	254,124	2,645,608	45,498	48,621	254,125
Total	24,811,455	382,725,323			

The Western Reserve, embracing a tract of about three millions eight hundred thousand acres, is in general better adapted to grazing and dairying than to the growth of cereals; consequently we do not find a solitary county within the original limits of the Reserve, which, in 1856, produced one hundred thousand bushels of wheat, nor with the exception of Erie and Huron counties, that has, during the same period, produced half a million bushels of corn.

But the cereals are by no means neglected on the Reserve; Geauga county producing in 1856 the least of any of the Reserve counties; it then produced 26,426 bushels of wheat, and 126,259 bushels of corn.

The year 1856 may, perhaps, be considered a year of rather less than average productiveness, so far as cereals are concerned. Taking the products of 1856 as a basis, the estimates will be within the truth, which, after all, is perhaps the safest course to be pursued. In 1856 Butler was the only county in the State that produced more than 600,000 bushels of wheat; Montgomery the only one that produced over 500,000, and under 600,000; Greene, Stark and Preble each over 400,000, and under 500,000. In 1850 Stark produced over 1,000,000 bushels.

The most important crop in the State is the wheat crop; the extent of its culture is indicated in the following exhibit compiled from authentic sources:

Digitized by Google

WHEAT.

The following Tables exhibit the number of acres in each county in the State, cultivated in Wheat during the years 1850, '51, '52, '53, '54, '55, '56, *and* '57.

COUNTIES.	ACRES SOWN.							
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.
Adams	.....	15,972	20,183	18,901	23,140	22,968	26,891	33,461
Allen	14,872	15,560	14,054	12,820	10,338	5,788	6,801	13,240
Ashland	32,382	30,613	29,430	23,847	21,413	15,937	19,620	20,623
Ashtabula	.....	4,301	2,236	4,865	5,728	9,513	6,369	5,188
Athens	17,468	15,843	17,125	12,961	16,043	18,929	19,195	24,915
Auglaize	9,721	10,900	12,226	10,950	11,084	6,482	7,624	10,394
Belmont	39,189	38,106	34,738	33,331	34,918	35,514	32,893	37,686
Brown	24,980	20,320	20,891	25,058	24,859	26,491	48,407	34,749
Butler	31,131	26,242	24,947	24,804	29,278	31,294	40,145	42,396
Carroll	34,915	29,412	27,934	21,014	22,695	23,677	22,674	22,462
Champaign	34,542	32,676	33,607	30,157	28,657	23,896	26,182	34,979
Clark	24,488	25,030	24,018	24,249	25,021	24,520	25,775	31,315
Clermont	.....	21,484	17,671	17,665	18,912	19,965	22,653	34,738
Clinton	17,626	17,562	16,778	14,045	15,882	18,701	21,158	27,908
Columbiana	35,721	29,909	28,829	25,854	23,423	23,015	23,755	23,646
Coshocton	47,811	37,487	37,888	35,980	35,607	23,515	22,812	25,816
Crawford	21,599	20,164	18,029	15,073	10,627	8,006	9,939	14,250
Cuyahoga	6,711	7,337	8,175	4,149	8,405	8,720	8,089	2,987
Darke	.....	24,217	20,919	24,189	22,224	27,416	29,651	36,186

Digitized by Google

Defiance	6,583	6,076	6,725	6,248	5,466	3,107	3,700	6,549
Delaware	.....	12,075	11,445	8,857	9,267	9,255	9,749	13,670
Erie	12,578	11,142	9,789	7,781	6,998	8,740½	3,990	6,218
Fairfield	39,472	37,648	36,579	34,011	36,464	33,651	32,104	38,705
Fayette	9,901	9,502	8,380	6,686	9,375	10,175	10,732	15,542
Franklin	16,071	17,710	17,590	12,457	15,979	16,713½	18,197	28,045
Fulton	8,117	8,360	8,668	7,025	8,207	5,654	3,805	5,449
Gallia	13,986	13,891	14,372	14,787	18,024	19,483	22,883	28,938
Geauga	4,386	3,757	3,563	2,688	3,140	4,889	3,479	3,823
Greene	28,550	24,618	24,209	23,806	23,410	24,948	27,987	34,189
Guernsey	35,402	28,523	29,766	28,410	26,283	26,927	24,717	25,989
Hamilton *	.....	6,365	6,076	8,495	9,869	10,417¾	13,723	19,958
Hancock	23,451	24,488	22,080	17,884	16,399	6,845	8,839	15,520
Hardin	6,024	8,179	6,153	3,756	2,282	2,284½	2,840	8,125
Harrison	31,415	27,466	24,795	21,293	21,792	18,084	18,317	19,040
Henry	.....	1,849	2,265	1,772	586	.....	941	2,770
Highland	38,394	32,967	30,465	27,509	31,671	34,714	35,590	48,485
Hocking	17,989	16,503	17,026	15,608	16,211	18,446	19,221	22,689
Holmes	38,704	26,875	26,875	23,509	26,237	17,906	18,976	22,258
Huron	21,882	18,770	17,981	13,856	11,155	6,077	6,598	12,745
Jackson	10,428	12,141	11,847	11,387	13,415	14,461	15,283	18,212
Jefferson	35,062	29,540	28,975	19,401	24,618	21,335	20,493	21,795
Knox	39,936	28,627	35,886	21,875	19,497	12,328	13,091	18,300
Lake	5,183	5,761	5,506	4,474	4,571	5,128	4,589	4,304
Lawrence	2,959	2,030	2,128	2,128	3,528	5,205	7,796	12,081
Licking	48,187	39,921	40,610	31,943	31,796	22,771	24,388	28,323
Logan	39,525	24,271	25,640	20,208	19,758	12,483	14,964	23,194
Lorain	11,555	11,156	9,076	6,519	3,767	1,517	2,174	4,206
Lucas	. .....	4,289	4,085	3,878	3,221	1,056¾	1,099	2,490
Madison	4,019	5,763	5,359	4,089	5,119	6,258	6,121	9,711
Mahoning	16,781	16,563	13,777	12,575	13,582	12,087	12,327	12,593

Digitized by Google

WHEAT—*Continued*

COUNTIES.	ACRES SOWN.							
	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.
Marion	8,294	8,031	6,777	4,960	3,612	5,056	5,767	8,704
Medina	17,698	15,619	13,961	11,268	8,721	10,274	10,707	11,575
Meigs	.....	12,117	13,253	11,705	14,873	16,940	17,995	22,044
Mercer	8,272	11,479	10,528	10,632	11,789	10,167	9,865	13,968
Miami	26,563	26,218	25,298	25,800	24,414	27,127	24,024	33,269
Monroe	24,131	19,484	20,485	18,294	20,599	24,895	22,770	29,538
Montgomery	36,094	32,128	28,000	28,182	28,768	26,434	33,628	21,685
Morgan	42,578	28,280	29,497	26,730	27,578	27,797	35,071	32,155
Morrow	19,389	17,100	15,602	9,071	6,801	4,612	6,663	10,895
Muskingum	58,649	50,244	53,740	45,668	46,727	41,511	41,544	42,225
Noble	.....	19,461	20,749	15,984	17,226	20,533	18,226	22,175
Ottawa	3,309	2,933	2,766	2,634	2,652	1,429½	1,268	2,089
Paulding	1,389	1,174	1,401	1,411	480	212	816	1,395
Perry	34,766	31,008	31,378	26,769	27,944	26,111	27,042	27,656
Pickaway	20,152	19,425	18,899	13,511	18,025	22,969	22,995	34,119
Pike	6,001	6,124	6,413	6,306	7,058	8,060	7,686	13,400
Portage	14,664	12,951	11,466	9,313	9,859	12,563	10,863	16,245
Preble	28,172	26,452	23,919	25,279	25,350	26,825	30,655	42,634
Putnam	7,432	8,471	7,444	7,810	5,290	2,165	3,340	6,698
Richland	41,219	35,080	35,167	26,306	22,526	15,873	21,075	24,747
Ross	25,832	25,320	24,637	21,533	24,294	28,580	28,897	41,100
Sandusky	17,193	13,684	14,759	13,288	14,376	7,872	6,194	11,382

Digitized by Google

Scioto	.....	3,254	3,577	5,451	6,867	8,389	8,568	14,972
Seneca	40,895	40,160	34,443	32,070	33,078	17,064	20,168	30,296
Shelby	13,960	15,075	15,881	16,346	15,252	11,875	12,312	16,280
Stark	53,407	47,864	44,504	41,471	43,369	45,804	41,212	51,419
Summit	23,728	21,599	20,831	19,098	16,841	20,007	19,894	20,496
Trumbull	10,718	11,667	10,346	8,246	8,123	10,421	8,021	8,499
Tuscarawas	49,077	41,378	43,924	36,227	39,175	38,740	36,054	36,332
Union	5,836	8,502	8,346	6,285	4,947	5,982	7,420	11,105
Van Wert	4,481	5,519	5,405	5,553	4,404	3,617	2,701	6,439
Vinton	8,287	8,660	8,957	8,079	9,120	9,928½	10,768	13,463
Warren	25,990	24,258	23,327	19,450	20,885	24,997	25,675	34,735
Washington	21,236	19,037	19,370	18,111	21,396	27,798	29,717	35,152
Wayne	.....	43,805	43,568	38,006	38,304	33,364	32,479	37,952
Williams	.....	8,241	9,744	10,346	10,446	8,498	4,572	9,012
Wood	.....	5,580	5,014	3,945	3,314	1,417	2,393	5,141
Wyandotte	.....	9,914	.....	6,486	6,614	5,136	5,980	11,490
Total	1,658,106	1,657,252	1,624,715	1,421,826	1,475,935	1,407,773	1,478,164	1,823,147

*Only seven townships made report.

Digitized by Google

BUSHELS OF WHEAT GATHERED.

Counties.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.
Adams	.....	149,140	258,057	191,096	225,895	269,006	284,695	381,653
Allen	231,277	299,426	147,494	116,680	26,532	86,579	56,935	200,036
Ashland	633,996	573,176	473,331	206,815	65,826	184,990	176,338	306,562
Ashtabula	.....	75,905	38,685	75,102	71,531	168,532	54,779	84,888
Athens	221,369	196,008	209,653	148,424	167,762	253,999	190,087	318.151
Auglaize	139,788	162,361	130,408	96,615	37,254	86,050	70,408	106,296
Belmont	667,311	563,467	508,480	394,852	320,965	555,548	375,588	408,566
Brown	360,093	207,820	256,456	316,721	246,378	317,400	321,380	479,882
Butler	529,890	377,738	397,625	367,030	396,266	447,813	636,861	789,569
Carroll	577,285	427,714	325,131	155,132	159,718	356,129	106,142	208,764
Champaign	665,878	600,641	535,510	410,294	125,156	354,136	331,322	406,164
Clark	491,954	447,319	421,968	393,488	249,519	393,714	357,480	420,780
Clermont	.....	203,498	248,257	236,824	175,478	378,928	271,901	557,757
Clinton	288,995	201,445	216,209	198,581	175,076	282,585	281,449	444,528
Columbiana	606,261	459,887	390,791	264,293	126,258	363,996	146,080	305,824
Coshocton	862,809	519,094	597,310	338,999	207,611	184,367	173,754	182,552
Crawford	409,648	310,848	128,812	165,185	18,669	95,505	138,028	208.279
Cuyahoga	97,966	125,357	48,290	51,669	18,651	47,123	31,285	36,845
Darke	.....	373,939	324,958	298,593	181,786	370,478	318,528	495,212
Defiance	94,207	88,009	84,124	71,151	18,218	130,484	29,550	76,888
Delaware	.....	175,767	127,800	107,665	92,509	23,537	119,868	158,800
Erie	297,587	214,194	162,814	122,810	31,149	50.599	50,025	118,181
Fairfield	690,089	609,724	569,328	469,004	343,058	403,806	596,928	582,187
Fayette	149,564	119,480	113,124	107,672	90,549	185,889	151,409	258,920

Digitized by Google

Franklin	294,162	275,781	309,784	180,862	206,362	265,760	251,928	448,641
Fulton	127,705	139,055	118,179	118,644	49,611	46,807	24,224	78,385
Gallia	125,433	124,981	156,768	145,086	177,272	258,880	78,219	404,178
Geauga	59,528	61,040	54,675	86,615	40,148	91,661	26,426	48,822
Green	576,258	388,195	442,598	378,257	388,785	386,126	423,000	537,041
Guernsey	564,787	367,592	372,222	213,246	221,689	298,618	187,780	176,488
Hamilton	.....	79,264	92,110	58,214	138,829	159,138	218,441	380,224
Hancock	355,051	359,520	146,928	169,820	16,229	99,452	94,989	234,914
Hardin	88,469	98,808	86,852	41,884	9,259	86,280	30,021	107,418
Harrison	532,778	430,645	318,174	168,305	119,109	224,610	132,600	190,666
Henry	.....	25,959	26,670	21,423	1,277	.....	10,877	55,955
Highland	495,392	304,201	358,726	285,078	285,937	444,172	388,098	756,571
Hocking	220,437	182,061	100,950	177,678	166,885	236,526	180,974	284,120
Holmes	640,459	426,114	426,114	207,721	119,141	132,161	150,482	309,300
Huron	441,604	331,428	282,581	171,703	18,086	66,817	80,150	237,655
Jackson	94,861	94,163	116,469	111,308	132.570	150,963	108,061	220,973
Jefferson	616,180	469,401	349,589	188,708	165,521	280,398	147,711	205,987
Knox	762,267	446,645	505,377	116,771	45,590	110,318	120,206	232,633
Lake	82,286	100,889	85,329	65,102	38,713	87,310	48,721	41,571
Lawrence	25,959	15,186	16,067	24,347	27,247	71,605	76,607	168,724
Licking	849,116	587,270	507,326	290,855	214,574	241,200	239,360	289,942
Logan	795,542	378,290	372,639	266,205	89,731	191,360	166,644	209,459
Lorain	206,801	193,807	106,916	79,345	12,635	18,204	26,751	78,066
Lucas	.....	88,189	52,786	55,779	10,057	10,041	11,857	43,527
Madison	64,610	83,257	77,640	60,188	51,627	112,581	67,096	117,739
Mahoning	325,497	294,396	212,340	142,748	73,997	187,315	90,657	171,961
Marion	144,832	108,264	70,825	69,189	26,175	79,541	72,729	128,872
Medina	350,303	299,015	253,849	155,910	42,331	136,162	88,076	175,355
Meigs	128,593	142,645	166,392	144,028	189,261	221,393	185,899	338,270
Mercer	120,099	203,749	128,905	120,852	71,554	138,984	69,902	159,245
Miami	565,565	467,555	419,909	366,360	216,131	620,088	330,550	457,936

Digitized by Google

BUSHELS OF WHEAT GATHERED—*Continued.*

Counties.	1850	1851.	1852.	1853.	1854.	1855.	1856.	1857.
Monroe	801,219	232,770	217,500	145,229	199,901	869,157	207,894	411,724
Montgomery	788,784	566,952	497,870	464,437	881,373	409,384	502,210	625,015
Morgan	661,104	435,282	416,080	326,514	805,070	387,005	295,362	355,510
Morrow	364,432	246,995	104,766	77,820	21,361	57,742	79,584	156,567
Muskingum	1,003,096	754,619	801,975	489,377	403,774	482,042	352,362	824,011
Noble	.....	257,286	230,533	175,071	177,275	309,033	165,529	287,037
Ottawa	65,411	52,702	44,352	40,398	18,297	15,179	14,622	31,581
Paulding	19,588	13,858	17,304	18,470	314	2,243	8,337	12,897
Perry	537,900	418,694	421,286	292,164	214,733	318,507	238,712	309,377
Pickaway	338,829	295,964	274,257	213,168	238,807	356,764	277,816	531,442
Pike	52,596	45,708	60,641	55,727	64,115	79,276	62,438	164,321
Portage	255,402	232,563	193,375	132,555	92,769	252,297	94,189	232,952
Preble	471,605	375,561	341,896	298,298	222,490	429,681	443,516	670,484
Putnam	96,368	127,328	69,798	69,352	8,887	27,158	30,695	92,573
Richland	795,213	557,059	470,643	242,977	45,669	208,723	247,321	335,636
Ross	359,046	296,430	327,603	291,990	295,613	438.440	374,166	666,000
Sandusky	330,344	244,822	210,466	198,656	22,018	75,168	71,424	177,508
Scioto	.....	29,117	38,188	60,967	73.288	98,956	82,708	253,623
Seneca	836,824	725,513	428,052	402,987	26,270	172.085	245,850	482.651
Shelby	239,820	243,110	194,501	219,956	68,456	153,294	127,841	180,425
Stark	1,071,177	892.233	956,513	612,256	493,066	923.102	433,214	997,790
Summit	485,404	415,890	460,132	324,882	178,073	416,398	197,821	374,641
Trumbull	190,017	205,464	156,411	108,117	71,497	172,173	61,637	97,356
Tuscarawas	883,071	656,172	669,181	437,223	316,793	489,288	222,327	390,435

Digitized by Google

Union	103,202	122,826	92,601	70,701	88,759	84,553	80,276	123,004
Van Wert	60,604	78,950	61,734	59,467	24,818	46,424	22,825	91,408
Vinton	77,244	88,900	87,470	78,809	87,588	105,097	81,547	148,148
Warren	447,042	825,118	369,311	299,048	297,954	338,674	898,599	603,095
Washington	264,816	224,800	243,681	222,594	245,949	373,107	818,600	513,888
Wayne	.....	832,059	885,510	478,560	217,381	426,746	278,895	650,280
Williams	.....	105,272	186,416	140,643	67,648	73,009	34,195	101,978
Wood	.....	88,274	52,111	41,669	8,164	19,626	29,098	81,849
Wyandotte	.....	141,226	.....	80,968	23,453	80,193	83,388	154,208
Total	28,769,189	25,309,225	22,962,774	17,118,311	11,819,110	19,569,820	15,388,887	25,397,614

Digitized by Google

The crop of 1857 was greater in area and more prolific than that of the preceding year. From the preceding statistical table, it will be seen that the wheat crop has gradually been decreasing, not only in the area devoted to it, but in the quantity produced per acre. The crop of 1850 was sown on 1,658,106 acres, yielding upward of seventeen bushels per acre, on an average, throughout the State. In 1855, there were more than 250,000 acres less in wheat, producing less than fourteen bushels per acre. In 1854, the average production was less than eight and a half bushels per acre, owing to the depredations committed by the red weevil, or midge (Cecidomyia tritici) in some portions of the State, and to freezing out, or winter-killing in other portions. The next year, 1855) however, almost 70,000 acres *less* (than in 1854) produced about seven and a half million bushels *more* of wheat.

If the wheat cultivators of Ohio had practiced a general system of underdraining their clayey soils, and had thoroughly understood the natural history of the midge, a loss of nearly ten million bushels of wheat in 1854 could have been avoided. Owing to the depredations of the midge and other insects, and owing, also, to "winter-killing," or "freezing out," the farmers of Ohio have lost nearly twenty million bushels of wheat during the five years last past. From 1850 to 1853, both inclusive, the crops averaged 14.6 bushels per acre; the crop of 1854 then *should have been* 21,548,651 bushels, instead of which, it was 11,819,110 bushels only, being a decrease from the average aggregate of 9,729,541. The crop of 1856 was less than the average from 1850 to 1853 by 6,247,357; the losses attributable to destructive insects, want of underdraining, etc., may be stated as follows:

1853	3,640,348	bushels.
1854	9,729,541	"
1856	6,247,357	"
Total	19,617,246	

Or about 14 per cent. of the entire amount produced from 1850 to 1856, both inclusive, or 30 per cent. of the amount produced during the four years from 1853 to 1856.

Digitized by Google

There is no industrial pursuit in the State other than that of agriculture which could sustain such extensive losses without seriously embarrassing, not only those immediately concerned, but the entire industrial community.

There appears to be a gradual change taking place in the locality of the wheat region of Ohio. From the completion of the Ohio canal wheat has been the great staple of export in the following counties, viz., Belmont, Coshocton, Muskingum, Fairfield, Guernsey, Jefferson, Harrison, Holmes, Stark, Tuscarawas and Wayne.

Of all these counties, Stark appears to be the only one which retains its former position as a wheat-growing county—all the others having greatly degenerated in this respect; while on the other hand, the great corn counties of the Miami and Scioto vallies have taken the position formerly occupied by them.

The counties of Butler, Warren, Preble, Clermont, Hamilton, Darke, Brown, Highland, Ross, Pickaway and Franklin raised more wheat in 1857 than in 1850, which was the year of the largest crop, and more than was ever raised in one year by these counties. These counties lying in the southern half of the State seem to suffer much less from the ravages of insects; and thus their crops correspond more nearly to the number of acres planted. The relative amount of wheat raised in these counties in 1850, 1855 and 1857 is thus expressed:

Counties.	1850.	1855.	1857.
Brown	860,093	317,400	479,882
Butler	529,890	447,813	789,569
Clermont	.....	378,928	557,757
Darke	.....	370,478	495,212
Hamilton	.....	159,133	380,224
Highland	495,392	444,172	756,571
Franklin	294,162	265,760	443,641
Pickaway	338,829	356,764	531,442
Preble	471,605	429,681	670,484
Ross	359,046	438,440	666,000
Warren	447,042	338,574	603,095
Aggregate		3,947,143	6,373,877

Digitized by Google

The following were the products of wheat in the same number of counties, in what was called the wheat region:

Counties.	1850.	1855.	1857.
Belmont	667,311	555,548	408,566
Coshocton	862,809	184,367	182,552
Fairfield	690,089	403,808	582,137
Guernsey	564,787	293,613	176,483
Jefferson	616,180	280,398	205,987
Muskingum	1,003,096	482,042	324,011
Harrison	532,778	224,610	190,666
Holmes	640,459	132,161	309,300
Stark	1,071,177	923,102	997,790
Tuscarawas	883,071	489,238	390,435
Wayne	.....	426,746	650,280
Aggregate	7,531,757	4,395,633	4,413,207

These tables are very significant. In eleven counties in the southern part of the State, the wheat crop of 1857 was 2,426,734 bushels *greater* than in 1855. In eleven counties of what is called the "Wheat Region," the *reduction* is 3,118,550 bushels since 1850. In fact, a close analysis shows that almost the entire reduction in the wheat crop of Ohio is in a few counties only. The doctrine of a rotation of crops—or at least of not raising wheat as a continual crop, appears to be very clearly indicated from the above tables and statement.

Plow deep, then; bring up the phosphates from below, and then apply your manure. Soils must be plowed deep to produce good wheat—first, to get the phosphates, and, secondly, to give the roots of the wheat plants a chance to run deep. One acre plowed twelve inches deep will produce more wheat than four acres plowed six inches deep.

Again we say—plow deep—save all your manure, and use it freely; apply your lime, clover, and plaster; rotate your crops; and instead of thirteen bushels to the acre being an average crop of wheat, you will just as easily get an average of twenty-five. Turn your attention to renovating your lands,

Digitized by Google

instead of dreaming of the fertile West, and make Ohio what she was intended to be, the granary of the Union. Unless our farmers turn their attention, and very soon too, to the renovation of their wheat lands, even *Ohio will soon be among the non-producing wheat lands.* That portion of Canada, which is included in the wheat region, is no longer profitably cultivated with wheat, and has fallen off, in wheat production, from 22,981,244 bushels to 942,835 bushels in a year. This falling off of over twenty-two millions of bushels of wheat in the annual crop was gradual, but took place between 1827 and 1844. This has curtailed the product of the crop in the wheat-growing regions immensely, and Canada may be left out of the wheat region.

Wheat requires "*a large mixture of clay in the soil for its perfect growth,*" for want of which the territory west of Ohio can never be a permanent wheat-growing region, and Virginia, Maryland, and Delaware, and most of New England, are exhausted by long continued cropping without renovation. It will be seen, then, that the wheat region is narrowed down to very confined limits, and, what is more lamentable, these limits are becoming less productive. It is on this account that we call attention to this all-important subject. Unless our farmers are roused up to this subject, the small remaining wheat region will be so nominally only; or, like Illinois, must soon be turned to the production of spring wheat.

In a work called "American Husbandry," published in England in 1775, the writer says: "Wheat, in many parts of the province of New York, yields a larger produce than is common in England. Upon good lands about Albany, where the climate is the coldest in the country, they sow two bushels and better to an acre, and reap from twenty to forty. The latter quantity is not often had, but from twenty to thirty bushels are common, and with such bad husbandry as would not yield the like in England, and much less in Scotland." Such was the productiveness of the wheat lands of New York eighty years ago.

Digitized by Google

In 1845, the average per acre of that same wheat land, in Albany county, was only seven and a half bushels; in Dutchess county, only five bushels; Columbia county, six bushels; Rensselaer, eight bushels; and West Chester, seven bushels per acre. In northern Ohio we believe we may safely place the average product of wheat at thirteen bushels per acre. Now, after a cultivation of about half a century, our yield of wheat has decreased about one-half per acre. The process of diminution is still going on, and unless soon arrested by the application of proper manures, and a better system of tillage, our average product, like those parts of New York to which we have referred, will soon be between five and eight bushels per acre.

In England, where the land has been in cultivation for centuries, the average yield is thirty-six bushels per acre; in Scotland, thirty bushels; and in England crops have been raised as high as eighty-eight bushels to the acre.

Now it may be laid down as an axiom that, climate and local circumstances being the same, what one soil will produce, another, by scientific cultivation, may be made to produce; and that the farmer, from a like amount of skill and labor in the cultivation of the soil, may anticipate the same results that have attended like efforts in other countries. If they pursue the exhausting process that has impoverished Virginia and some other States, they will reap an abundant crop of poverty and exhaustion. The work is going on rapidly. The estimated loss, by exhaustion, in the United States, is, annually, $30,000,000. This is equivalent to a loss of $500,000,000 capital, at six per cent. If, by scientific cultivation and manuring, our farmers will arrest this system of exhaustion, they will restore this capital; and these lands that now produce from five to thirteen bushels of wheat to an acre, can be made to produce as they do in England—twenty, forty and eighty bushels.

As we have so long looked at the vast West as an inexhaustible wheat region, it is hard to bring ourselves to a

Digitized by Google

belief that it is not such, and still more so to believe that it is mostly a desert, incapable of producing anything, much less good wheat crops. That our farmers may know that what we say is literally true, we quote from Professor Henry, secretary of the Smithsonian Institute. He says:

"We are nearer the confines of the healthy expansion of our agricultural operations over new ground, than those who have not paid definite attention to the subject could readily imagine. The whole space of the West, between the 98th meridian and the Rocky Mountains, denominated the great American Plains, is a barren waste, over which the eye may roam to the extent of the visible horizon, with scarcely an object to break the monotony. From the Rocky Mountains to the Pacific, with the exception of the rich but narrow belt along the ocean, the country may also be considered, in comparison with other portions of the United States, a wilderness, unfitted for the use of the husbandman.

"In traversing this region, whole days are frequently passed, without meeting a rivulet, or stream of water, to slake the thirst of the weary traveler. Between the parallels of 32° and 33°, occurs the great Colorado desert, extending to the river of the same name, which empties into the Gulf of California. The entire district is bare of soil and vegetation, except a few varieties of Cactus. Over the greater portion of the northern part of Sonora, and the southern part of New Mexico, sterility reigns supreme.

"We have stated that the entire region west of the 98th degree of west longitude, with the exception of a small portion of western Texas and the narrow border along the Pacific, is a country of comparatively little value to the agriculturist—and this line, which passes southward from Lake Winnepeg to the Gulf of Mexico, will divide the whole surface of the United States in two nearly equal parts."

It will thus be seen that comparatively all the wheat region is in the eastern half of the United States; that all west of longitude 98°, which is a line from the west side of Lake

Digitized by Google

Winnepeg to the west end of the Gulf of Mexico, may be set down not only as a non-wheat-producing region, but also as mostly an unproductive desert.

In this manner we see that "one-half of all the territory of the United States" is unproductive. Of the balance, Maryland, Virginia, Delaware, and New England may be said to be exhausted—much of New York nearly so. Tennessee is devoted to cotton, Kentucky to tobacco, and Missouri to hemp, narrowing down the area of the wheat region to a comparatively small territory.

Of this small territory, which we have designated as the wheat region, Ohio may be said to be the western verge of the real wheat-*producing* section. As this is contrary to the views of most people, who think the rich prairies of Illinois are great wheat-producing regions, we will give an extract from "*Emery's Journal of Agriculture*," published at Chicago, the great wheat market of Illinois.

"South of [Minnesota, northern Wisconsin, and Michigan], the want of the snow coming to protect the young plants from the almost constant freezing and thawing of winter, and drying winds of March, make it, in most seasons, a very uncertain crop. We have known good crops of winter wheat on sod land, in the district indicated, but these are exceptions to the general rule; *nor do we believe that winter wheat, on an average, has ever paid the expense of its culture in the section now noticed.* From the fact that its culture in that section is generally abandoned, and spring wheat largely cultivated in its place, we think the question is fully settled."

This authority, we think, fully sustains our position, that Ohio is the most westwardly State in the wheat-producing region. Indiana and Illinois are better adapted to other crops, or to spring wheat, than to the choice winter wheat of Ohio, Pennsylvania, and western New York. This narrows down the wheat region to a small territory, and instead of the vain boast that we can feed the world from our surplus wheat, indicates that we must husband our resources, and stop the dete-

Digitized by Google

rioration of our soil by the liberal application of manure and better tillage, or we shall soon be importers of wheat instead of exporters. The most desirable portions of our territory have changed owners, and now belong to individuals instead of the government. If these are exhausted the like can not be again purchased.

Our farmers, then, must look to it. They must preserve those wheat lands that are not exhausted, and renovate those that are, or we shall soon be out of the pale of the wheat-*producing* section, though in the natural wheat region. The tide of population that is moving westward must soon stop, as they will reach the verge of not only the wheat region, but of the agricultural region. It must soon return eastward in search of the wheat-producing region; and to enable them to find it a different system of tillage and manuring must be pursued.

The following statement will, to say the least, be a matter of interest and for future reference. Therefore, we have choser it as an appropriate conclusion of this chapter.

Digitized by Google

STATEMENT

Showing the Annual Average Export Price of Flour at New York from 1800 *till June* 30, 1855; *also, The Annual Average Price of Flour in the Cities of Boston, New York, Philadelphia, Baltimore, New Orleans, and St. Louis, from* 1800 *till June* 30, 1855.

Years.....	Export Price.	Boston.....	New York...	Philadelphia..	Baltimore.....	New Orleans.	St. Louis .....
1800	$10.00	$11.00	$ 9.38	$ 9.75	$11.42	.....	.....
1801	13.00	12.10	10.14	10.85	11.42	.....	....
1802	9.00	8.17	6.19	6.94	7.00	.....	.....
1803	7.00	7.55	6.01	6.75	6.50	.....	.....
1804	7.75	8.97	7.15	7.81	7.33	.....	.....
1805	13.00	11.25	9.59	10.15	12.08	.....	.....
1806	7.50	8.25	7.13	7.15	7.33	.....	.....
1807	8.25	7.73	6.76	7.10	7.50	.....	.....
1808	6.00	6.25	5.15	5.59	5.75	.....	.....
1809	7.50	7.63	6.79	6.43	6.50	.....	.....
1810	8.25	9.42	8.77	9.37	9.40	.....	.....
1811	10.50	10.42	9.05	10.40	10.67	.....	.....
1812	10.75	10.90	9.08	9.95	10.12	.....	.....
1813	13.00	14.67	7.76	9.29	10.17	$18.50	.....
1814	14.50	14.57	7.76	7.67	8.50	9.00	.....
1815	9.25	8.95	8.17	8.68	7.92	9.00	... .
1816	7.37	9.40	9.34	9.75	8.67	9.30	.....
1817	14.75	12.27	11.72	12.12	10.31	12.50	.....
1818	10.25	10.50	9.42	9.85	9.59	10.83	... .
1819	8.00	7.70	6.79	7.19	6.56	9.62	.....
1820	5.37	5.25	4.81	4.94	4.65	6.20	.....
1821	4.25	4.42	4.85	4.92	4.64	6.28	.....
1822	7.00	6.94	6.39	6.48	6.36	5.75	.....
1823	7.75	7.34	6.93	6.90	6.89	6.68	.....
1824	6.62	6.07	5.93	5.62	5.54	6.25	.....
1825	5.37	5.57	5.19	5.00	4.88	4.91	.....
1826	5.25	5.24	5.00	4.69	4.78	4.49	.....
1827	8.00	5.64	5.14	5.27	5.15	5.12	.....
1828	5.50	6.14	5.50	5.29	5.48	5.36	.....
1829	5.00	6.81	6.54	6.25	6.37	7.20	.....
1830	7.25	5.26	5.08	4.83	4.86	4.98	.....
1831	5 62	6.05	5.84	5.82	5.61	5.47	.....
1832	5.87	6.29	5.87	5.62	5.79	6·84	.....
1833	5.50	6.11	5.70	5.85	5.69	5.28	$4.93

Digitized by Google

Years.....	Export Price.	Boston.....	New York....	Philadelphia.	Baltimore....	New Orleans.	St. Louis.....
1834	$ 5.50	$ 5.42	$5.07	$5.21	$4.99	$5.19	$4.50
1835	6.00	6.42	6.00	5.75	5.84	6.35	6.25
1836	7.50	8.50	7.78	7.44	9.92	8.55	8.00
1837	10.25	10.18	9.69	9.75	9.43	9.10	9.12
1838	9.50	8.25	8.02	7.81	7.84	8.67	7.87
1839	6.75	7.20	7.40	6.89	6.65	6.57	7.19
1840	5.37	5.51	5.17	5.22	5.00	4.93	4.93
1841	5.20	5.77	5.39	5.34	5.31	5.38	4.75
1842	6.00	5.67	5.67	5.47	5.20	4.54	4.56
1843	4.50	4.87	5.07	4.60	4.36	4.18	3.75
1844	4.75	5.13	4.61	4.34	4.31	4.44	4.50
1845	4.51	5.32	5.00	4.69	4.63	4.38	4.93
1846	5.18	5.53	5.19	4.79	4.53	4.38	4.50
1847	5.95	7.17	6.80	6.02	6.21	5 54	4.93
1848	6.22	6.43	5.71	5.67	5.52	4.76	5.25
1849	5.35	6.00	4.96	4.84	4.83	4.61	5.43
1850	5.00	6.00	4.86	4.97	4.89	5.81	6.25
1851	4.77	5.25	4.19	4.38	4.18	4.00	4.88
1852	4.24	5.20	4.96	4.23	4.26	4.10	5.23
1853	5.60	6.27	5.51	5.47	5.39	5.48	5.08
1854	7.88	9.25	8.02	8.14	8.13	7.60	6.09
1855	10.10	10.25	9.06	9.62	9.57	9.36	7.88

Amount and Value of Exports of Wheat and Flour from the U. S. at Decennial Periods.

Date.	WHEAT.		FLOUR.	
	Bushels.	Value.	Bbls.	Value.
1790	1,018,339	....	619,681	....
1800	239,929	....	1,102,444	....
1810	216,833	....	1,445,012	....
1820	25,821	20,925	1,056,119	4,298,043
1830	408,910	523,270	1,806,525	9,938,458
1840	868,585	822,881	1,515,817	7,756,646
1850	1,026,725	1,025,732	2,202,335	10,524,331

NOTE.—The price of Flour for New Orleans and St. Louis could not be obtained for earlier years than those respectively given.

Digitized by Google

CHAPTER XIV.

CULTURE OF WHEAT.

Soil.—The culture of the soil is the chief characteristic of civilization as distinguished from barbarism or savageism, and the culture of the wheat plant more especially marks this difference. In the early periods of the history of the human race, herds and flocks were pastured on perennial grasses which grew on the hill-sides and in the woodlands, but mankind did not then sufficiently understand the laws of Nature to reproduce by his own care and attention the plants which his herds and flocks had exterminated; therefore as soon as the pasture became scanty by constant cropping, new locations were sought—habitations became temporary and tribes of mankind were necessarily nomadic. But a new era dawned upon the history of mankind when it was discovered that plants could be reproduced by culture; when for the first time it was proclaimed that if the seeds of plants were carefully placed in the soil appropriately prepared and at the proper season, the plant would spring up from the seed as a Phœnix from its ashes. In commemoration of this important discovery the ancients instituted rites and ceremonies which were religiously observed. The discovery produced a demand for implements with which to scarify or scratch the surface of the soil and to prepare a "*seed bed*" for the seed;—to produce these implements required skill and labor, and thus was inaugurated a branch of industry which from that day until the present has been unable to supply the demand. The progress of Agriculture—the introduction of better and more efficient implements belong rather to the History of Agriculture, than a Treatise on the Wheat Plant; it may therefore not be pertinent to

Digitized by Google

enumerate any of the many changes which have been made. The first implements were necessarily exceedingly rude in construction, uncouth in appearance and unwieldy to the operator. The primitive plow! spade! and sickle! What a theme for an antiquary! And yet who shall dare deny that the rude plow, shod perhaps, by some ruder son of Vulcan, the sickle ill-favoredly forged, and the spade made ruder than either, have not determined the fate, secured the happiness and civilized the one half of mankind?

The culture of the soil although it has engrossed the constant attention of at least one-fourth of the civilized portion of mankind from the days of the first Thinite King of Manetho's Egyptian Dynasties down to the present time, remains almost as much an unsolved problem as in the days of the Ptolemies. Since the days of the last Egyptian King, a new continent has been not only discovered but peopled;—the little islands which Cæsar found sparsely inhabited by a race but little superior to savages have become the most densely populated portion of the globe, and produced works of art unsurpassed by any thing of antiquity. These little islands have grown mighty in power, and the sun never sets on their dominions! The Printing Press, Mariner's Compass, the application of steam as a motive power both to machinery and in navigation has been successfully consummated; the lightnings have been converted into "*mail-carriers;*" the size and distance of the planets have been accurately determined; the telescope and microscope invented, and the wonders of the planetary and microscopic world revealed; the composition of most of the substances found in Nature has been determined by the magic hand of the analytic chemist. Yet with all the progress made in arts and sciences, during the past two thousand years, we have made no progress whatever in ascertaining precisely how the plant elaborates organic from inorganic substances—we know very little more of the process by which the wheat plant prepares starch and gluten drawn from the earthy substances in which it grows and deposits them in its grains,

Digitized by Google

than was known in the days of Moses—to be sure we know that the roots receive the nourishment from the soil—possibly this was known to the ancients, and probably they believed the function of the roots to be no other than merely to fix the plant in its locality. Look at the long list of vegetable physiologists of the present and past century—men who have devoted not only a few months, but an entire lifetime in the endeavor to determine the structure and function of the different parts of plants; then turn to the list of names which shine the brightest in chemistry, and ask if any one of them—commencing with Black and ending with Liebig, have been able to produce any organic substance from inorganic ones by any chemical process? Can any of them from the same soil on which the wheat plant thrives and flourishes produce by any chemical process even a grain of starch, which is composed of carbon, hydrogen and oxygen only? No, no. Chemistry has not yet penetrated the arcana of Nature, and the little wheat plant has never yet revealed to man *how* or by what mysterious process it elaborates starch from the soil.

Is then the science of Agriculture so simple and can any one who runs, read it surely and correctly? Chemistry and physiology aided by untiring investigations and observation have placed the world in possession of many facts, from which innumerable hypotheses and "*fine spun*" theories were elaborated."

When the chemist analyzed the different portions of the wheat plant, as the stalk, chaff, grains, etc., it was very natural to suppose that if substances containing the elements absorbed by the plant were added to the soil, not only would its fertility not deteriorate, but the crops would absolutely be increased; the inference was rational as well as natural, but practice has not confirmed the hypothesis. The theory has not been borne out by practice for the reason that chemists as well as empirical agriculturalists forgot that the ingredients added to the soil *might* form new combinations with substances already there; form combinations which to say the least would not be favora-

Digitized by Google

ble to the growth of the plant. Thus if a soil is strongly impregnated with oxide of iron, and it receive a dressing of gypsum or Plaster of Paris, the sulphuric acid contained in the latter will combine with the iron, and form sulphate of iron, or "*copperas*," which is exceedingly deleterious to the growth of plants.

Chemists and agriculturists seem to have taken it for granted that the plant would take up each element as it was placed in the soil, and in cases where several elements were in combination that the plant would analyze or separate them. Some combinations are readily separated or analyzed, while others with the utmost difficulty only can be made to sever their union. For example, in a mixture of clover seed, mustard seed, flax seed, white sand and saw dust, a complete separation of the several substances is readily effected, and each particular seed, or grain of sand or saw-dust withdrawn from the combination; but in a mixture of flour, milk, sugar, water and yeast, the separation is infinitely more difficult—especially if the mixture (*bread*) is baked. The former of these mixtures is a mechanical combination, while the latter is a chemical one. Thus in the case referred to in the preceding paragraph they would not be affected by the sulphuric acid, or oxide of iron separately, but by the new combination, or copperas, and the result would be that instead of the Plaster of Paris acting as a fertilizer, it in that case at all events would act very injuriously.

"If we submit," says Leibig in his last work on Agricultural Chemistry (April, 1859), "to a close scrutiny the comportment of the salts of ammonia, nitrate of soda, and common salt toward soils, we find that not one of these salts acts in the same form in which it has been added to the ground. The salts of ammonia are immediately decomposed by the soil; the ammonia is retained, while the acid enters into combination with lime, magnesia, alkalies, or, in short, with any basic substance in immediate contact, and capable of combining with it. The action of these salts is therefore of a two-

Digitized by Google

fold nature. On the one hand, they enrich the soil with ammonia; on the other, their acid gives rise to new compounds which come into operation. The alkalies and alkaline earths which combine with the acid acquire thereby a greater degree of solubility, and are more readily diffused through the soil. If the ground is rich in magnesia or lime, the salts of these bases are formed; but their influence, with the exception of that of gypsum on certain plants, can not be estimated very high. The use of sal ammonia, instead of sulphate of ammonia, gives rise to chloride of magnesium and chloride of calcium, which acts rather unfavorably than otherwise on vegetation. That salts of these bases are generated by the action of soils on salts of ammonia, and that the new salts exert no particularly favorable influence on the increase of produce, are facts on which no doubt can rest."

When chemists announced to the world that wheat grains had been analyzed, and the component substances fully determined, both in a quantitative and qualitative sense, there were not wanting those who reasoned from effect to cause, and sought to find in the soil the elements which gave rise to the combinations and elements found in the plant and grain. This class of theorists regarded the plant as a mechanical machine, and appeared to take for granted that if certain substances in certain quantities were added to the soil the plant would mold them into wheat; it did not occur to them that the plant was a laboratory, and operated in a chemical, rather than in a mechanical manner.

The chemist announced that the *ash* of the grain was composed of silica, phosphoric acid, sulphuric acid, carbonic acid, lime, magnesia, peroxide of iron, potash and soda. It then was very natural to infer that these substances were withdrawn from the soil, and to insure continued fertility must be replaced. But as almost every soil contains these substances and elements in greater or less proportion, one would as naturally infer that *all* soils were wheat-producing soils. The next step to be consummated was to obtain an analysis of soils

Digitized by Google

in order to supply in an intelligent manner the materials in which the soil was deficient. This step undoubtedly was one in a right direction, but too much was presumed upon the ability of chemistry to determine. The quantity of some of the elements essentially necessary are so very small that it is difficult to determine whether they exist in too large or too small quantities. Of some, a single grain by weight in a pound of soil is all that is absolutely necessary, yet it is exceedingly difficult for the most expert chemist to determine whether one-fourth of a grain, a single grain, or ten grains exist in the pound of soil which he has analyzed. It is exceedingly difficult to determine from even a very correct analysis of soils, which is fertile and which is otherwise, as the following table, compiled from authentic sources, will exhibit at a single glance:—

	No. 1.	No. 2.	No. 3.	No. 3 *a*	No. 4.	No. 5.
Silica and siliceous sand	70.900	79.538	87.143	94.261	80.68	85.11
Alumina	6.996	7.306	5.666	1.376	6.55	4.51
Peroxide and protoxide of iron	6.102	5.824	2.220	2.836	2.57	3.15
Peroxide of Manganese	0.200	1.320	0.360	1.200		
Lime	2.218	0.619	0.564	0.243	0.35	0.77
Magnesia	3.280	1.024	0.312	0.310	1.53	0.63
Potash	0.130	0.200	0.120		1.40	0.74
Carbonate of Soda	6.556	0.024	0.025	0.240	0.53	0.22
Phosphoric acid, combined with lime	1.362	1.776	0.060	trace	0.05	0.12
Sulphuric acid, combined with lime	0.149	0.122	0.027	0.084	0.05	0.06
Chlorine	0.067	0.036	0 036	trace		
Humus soluble in alkalies	0.540	1.950	1.804			
Nitrogenous organic matter	0.000	0.286	1.011			
Humus, insoluble	1.500		1.072			
Carbonic acid					0.53	0.31
Organic matter					5.76	4.38

No. 1 is an analysis of a very *barren* field. (*Liebig*). Yet it has all the elements and combinations which are found in No. 2. Lime, magnesia and soda are especially abundant in it. No. 2, surface soil of alluvial land in Ohio, remarkable

Digitized by Google

for its great fertility. (*Liebig*). No. 3, surface soil of a mountainous district in the vicinity of the Ohio river, also distinguished for its great fertility. (*Liebig.*) Who will say that there is a closer agreement in the analyses of Nos. 2 and 3 than there is between Nos. 1 and 2? Yet No. 1 is sterile, while Nos. 2 and 3 are remarkable for their fertility. No. 3 *a* is an analysis of the subsoil of No. 3. No. 4 is an analysis of the prairie soil in Illinois (*Vœlker*), and No. 5 is an analysis of good wheat soil of England. The difference between Nos. 4 and 5 is absolutely less than between Nos. 2 and 3, and yet on the prairie soils of Illinois winter wheat can not be grown, while in England on soil of analysis No. 5, the best wheat in the world is produced.

No *absolute* guide as to the fertility or barrenness is obtained by a chemical analysis of the soil; nevertheless chemical analyses of soils should not be discouraged—they furnish many data from which important results are obtained. The fertility of the soil depends entirely on the amount of soluble matter it contains—or rather the soluble condition of the inorganic elements. The analyses of two soils may show that they are composed of precisely the same elements and in the same proportions, but the appropriate materials for the nutrition of plants may in the one have been in a proper, while in the other they were in an improper condition;—no one can judge from the analysis of a loaf of bread whether it was "*light*" and palatable, or whether it was "*sad*," and heavy and unpalatable; and yet the value of the bread depends entirely upon the condition in which it was.

The best exponents of the fertility of the soil are the indigenous trees and plants which are found upon it. Where nature is the planter we may rest assured that the seeds are placed in the soil most appropriate and congenial for them. A soil in which the common beech tree flourishes is always sure to retain considerable moisture, and as a general thing is a heavy, stiff clay; the pines and chestnut on the contrary are found flourishing in a light sandy soil. The observations of

Digitized by Google

all so strongly confirm this view that it may be accepted as a rule or law of nature. The organization of a plant is so delicate, and for its proper growth and development requires the materials of the soil to be so precisely adapted to its wants, that it can not flourish where any of the elements required by it are either wanting, or not in a proper condition of solubility in the soil. But as we do not know the *precise* requirements of each of the various species of trees and plants, we must take it for granted that the tree or plant itself, where it is fully and properly developed has found the requisite qualities and conditions; and from this fact we are enabled to determine many nice distinctions in the soil, when their general appearance of color, consistency, etc., are apparently identical.

The smallest indigenous plant that carpets the soil is just as much an exponent of the soil as the giant oak, and indicates the precise quality and condition just as much more definitely as its structure and organization is more delicate than the former. It is no argument that some plants are found growing on very different soils—this only proves that the plants have great tenacity of life, and great capacity of adapting themselves to the different circumstances in which they are placed. If, then, we rely upon plants of this character as exponents of the soil, we must be governed in our judgments more by their size than by their presence. Thus the common daisy thrives on a poor soil, but a thriving daisy is not necessarily an evidence of a poor soil. It naturally loves a good rich soil, but other plants may choke and smother it, and it may be found flourishing upon good land when from any cause even the grasses have failed.

Forest trees and indigenous plants may be regarded as exponents of the physical condition of the soil, rather than of its chemical composition. This assertion is amply confirmed by numerous facts. A soil on which oak, hickory and tulip, or yellow poplar are the principal trees of the native forest, is most suitable for the growth of wheat. Maple and beech producing soil is better adapted to spring or summer

Digitized by Google

crops—such as barley, corn and potatoes. The adaptation of "white oak soil" to winter wheat, and the beech and maple to spring crops, shows that it is the *physical* condition that determines the fitness of the soils for cultivated crops; for we have only to bear in mind that winter wheat, barley, oats and corn are identical in chemical composition. In both varieties of soil the chemical constituents which are necessary to the growth of beech, maple, oak, poplar and hickory, wheat, barley, corn and potatoes are present, but the physical condition, or mechanical texture of the two is different. This difference in the texture of soils seems to have a corresponding influence upon the healthy functions of certain kinds of trees and cultivated crops with that which an undrained and marshy soil is well known to have in this respect.

The following indications of soil from the character of trees found growing on it is compiled from Michaux's American Sylva:

WHITE OAK (*Quercus alba*). This oak is not common on lands of extraordinary fertility, like those of Tennessee, Kentucky, and the Genessee Valley in New York. He relates that he has traveled whole days in the spacious valleys watered by the western rivers without seeing a single stock. The White Oak is found in every exposure and on every soil which is not extremely dry or subject to long inundations; but the largest stocks grow in humid places, where it composes entire forests. Where the surface of the country is undulating, the soil yellow, consisting partly of clay with a mixture of calcareous stones, abundant crops of wheat are produced.

From this we are led to infer that the White Oak flourishes best on second rate soils—and also that wheat does best on second rate soils. In confirmation of this view a short quotation from "AGRICULTURE IN NORTH AMERICA," by Robert Russell (1857), may not be inappropriate. "In many of the rich valleys of the State of New York—such as the Mohawk —Indian corn is often cultivated on the same land for many years in succession. On these soils it is said to produce, on

Digitized by Google

the average of years, double, or even triple the number of bushels on an acre that wheat will do, for the latter is a most uncertain crop *on all rich and loamy soils.* Indeed throughout the American continent, wheat only grows well upon soils of moderate fertility, and such as are rather deficient in vegetable matter. The inferiority of the climate of America for the growth of wheat upon rich soils, is counterbalanced, however, by the superiority of its growth upon second-rate ones."

We believe it is the general experience that wheat in Ohio, grown upon very rich soils, is much more liable to mildew, rust, and to have tender straw, than upon soils of moderate fertility only.

The POST OAK (*Quercus obtusiloba*) is found wherever the soil is dry, gravelly, and unsubstantial; it forms a considerable portion of the forests which are composed principally of Black, Scarlet, Spanish, and Black Jack Oaks, Dogwood, etc.

WATER WHITE OAK (*Q. lyrata*) requires a more constantly humid soil than any other species of this genus in the United States—it is found exclusively in great swamps on the borders of rivers. In these gloomy forests it is united with the large Tupelo, White Elm, Wahoo, Plane tree, Water Bitternut Hickory, and Water Locust.

SWAMP WHITE OAK (*Q. prinus discolor*) is found only on the edges of swamps, and in wet places exposed to inundations, and not in forests at large. A thorough system of underdrainage will destroy all the Swamp and Water White Oaks, wherever it is practiced—the fact that even surface drainage is practiced to a considerable extent may account for the fact that forest trees, such as Beech and Elm, which depend for nutrition on the labors of the lateral roots, are rapidly dying out in many parts of this and other States.

CHESTNUT WHITE OAK (*Q. prinus palustris*) always chooses spots that are rarely inundated, where the soil is loose, deep, constantly cool and luxuriantly fertile. The Yellow Oak (*Q. prinus acuminata*) indicates a loose, deep, fertile soil. Rock Chestnut Oak (*Q. montana*) indicates a rocky soil. The small

Digitized by Google

Chestnut Oak (*Q. prinus chincapin*) indicates a barren soil. The Jack Oak, or Laurel Oak indicates a cool, humid soil. The Black Jack Oak (*Q. ferruginea*) is found on soils composed of red, argillaceous sand, mingled with gravel. The Bear Oak (*Q. Barristeri*) is never found [naturally] mingled with other shrubs in the forest, but always in tracts of several hundred acres, which it covers almost exclusively—it is found on, dry, sandy lands, mingled with gravel. The Black Oak (*Q. tinctora*) grows in any soil, but will flourish where the soil is lean, gravelly and uneven; is found in company with Post, Spanish and Scarlet Oaks, with Mockernut Hickory, and Yellow Pine. The Red Oak (*Q. rubra*) requires a fertile soil, and cool climate.

Black Walnut (*Juglans nigra*) grows in rich soil—not in sandy or wet—grows with Honey Locust, Red Mulberry, Shellbark Hickory, Black Sugar Maple, Hackberry, and Red Elm. All these trees indicate the richness of the soil in which they grow. The Butternut (*J. cathartica*) requires a good soil. Michaux says that sugar has been manufactured from the sap of this tree. The Bitternut, or Swamp Hickory (*J. amara*) requires an excellent soil, constantly cool and inundated.

The Mockernut Hickory, or White-heart Hickory (*J. Tomentosa*), requires a deep rich soil; it grows mingled with the Sweet Gum, Poplar, Sugar Maple, and Black Walnut. The Shellbark Hickory (*J. squarrosa*), grows almost exclusively in wet grounds which are inundated for weeks together; it is found in company with the Swamp White Oak, Red Flowering Maple, Sweet Gum, Buttonwood, and Tupelo. The thick Shellbark Hickory requires a similar soil. The Pignut Hickory (*J. porcina*) requires a moist but a better soil than the Mockernut.

The White Maple (*Acer eriocarpum*) is found on the banks of such streams only as have limpid waters and a gravelly bed; it is never found in swamps or other wet grounds inclosed in forests, where the soil is black and miry. The

Digitized by Google

Red or Soft Maple (*A. Rubrum*) requires a wet and frequently overflowed situation. The Sugar, or Hard Maple requires a moist yet fertile soil. The Box Elder (*A. negundo*) indicates a deep, fertile, and constantly moist soil. The Dogwood (*Cornus Florida*) flourishes in a gravelly soil. The Cucumber tree (*Magnolia acuminata*) requires a deep, fertile soil, and a moist atmosphere.

The Pawpaw (*Anona triloba*) is indicative of a soil luxuriantly fertile. The YELLOW POPLAR, or Tulip tree (*Liriodendron tulipifera*), grows in deep, loamy, and extremely fertile soils, which are neither too wet nor too dry. The Sycamore (*Platanus occidentalis*) grows in moist, cool grounds, requires loose, deep, and fertile soil—it never grows on dry lands, nor among White and Red Oaks.

The CRAB APPLE (*Malus Coronaria*) requires a fertile soil, and cool, moist place. The WHITE BIRCH (*Betula populifolia*) grows in scanty forests, and indicates a dry and meager soil. The Red Birch (*B. rubra*) grows with the White Maple and Sycamore. The *Yellow Birch* (*B. lutea*) indicates a cool, rich soil—it grows with Ashes, Hemlock, Spruce, and Black Spruce. The COMMON LOCUST (*Robinia pseudo-acacia*) requires a mild climate, and very fertile soil. LAURUS SASSAFRAS grows on all soils except those too wet or too dry.

The WILD CHERRY (*Cerasus Virginiana*) requires a rich soil; it grows with the overcup White Oak, Black Walnut and Red Elm. The OHIO BUCKEYE (*Pavia Ohioensis*) requires a loose, deep, and fertile soil—cool and humid climate—hence it is generally found on river banks. The COTTONWOOD tree (*Populus Canadensis, P. Argentea*) is indicative of a deep, unctuous soil. The Aspen (*P. tremuloides*) indicates lands of a middling quality. The White, Gray, or Hickory Poplar (*P. canescens*) most generally indicates a moist soil. The CHESTNUT (*Castanea vesca*) indicates a light, gravelly soil. The WHITE BEECH (*Fagus sylvestris*) indicates a deep, moist, and cold soil, while the Red Beech (*F. ferruginea*) indicates lands more dry—soils which are excellent for corn. The

Digitized by Google

HACKBERRY or *Hoop-ash* (*Celtis crassifolia*), is found in deep, fertile soils. It grows with Black Walnut, Butternut, Linn, Black Maple, and Elm. The White, Red, Green, Blue, and Black or Water Ashes (*Fraxinus*) are indicative of a deep, rich, yet very moist soil. The WHITE ELM and WAHOO (*Ulmus Americana*) are found in low, humid, but very substantial soils, in company with the Red Maple and Shagbark Hickory; but the Red Elm is seldom found with the White, and indicates a soil free from moisture. The Linn, or Basswood (*Tilia Americana*), grows with Sugar Maples and the White Oak. The Pines, Cedars, and Junipers, indicate a soil which is warm, dry, often sandy or gravelly, and is easily exhausted.

These observations were made by the Messrs. Michaux (father and son) more than half a century since. They are the more valuable because the forests were then in a very great degree undisturbed, and the trees grew where nature had planted them.

It may be laid down as a general rule, that a rich and varied natural vegetation, trees as well as plants, is indicative of a soil of good capacity; one which not only contains all the elements necessary for the growth of most cultivated plants, but free from any noxious substances, and in that physical condition to allow of its profitable cultivation; while on the other hand, a scanty vegetation, embracing few species only, indicate the absence of some important element, or some physical imperfection.

The class of farmers that emigrated from Pennsylvania to Ohio during the first thirty-five years of the existence of the State invariably selected very heavily timbered "white oak" lands as the best wheat lands.

The soil of Stark county may be divided into three distinct classes, and the settlement of these classes of lands is perhaps the criterion of the value of the empirical method of determining the value of lands for farming purposes. The first of these divisions embraces all the heavily timbered, white oak,

Digitized by Google

rolling lands. These lands occupy the greater portion of the county. The second division comprises a large district in the north-east portion of the county, known as the "*beech lands.*" The third division is a strip, varying from three to four miles in width, passing through the center of the county, known as the "*plains.*"

The lands comprised in the first division were first settled, cleared and cultivated—they are composed as a general thing of a "clayey loam" for surface soil, and a stiff clay subsoil. The Tulip tree, Linden, Poplar, and Walnut are very common on these oak lands.

The beech lands are low and level; scarcely any other than Beech timber is found on them; occasionally, however, an Elm, Water Ash, and Hickory are met with. The soil is a heavy, compact clay, in its natural state retaining excessive moisture nearly all the year, but when cleared is liable to "bake." Ditching and surface draining, however, have rendered these lands valuable for corn rather than wheat, although they are better adapted for meadows and grazing. They were settled next after the oak lands, and were then considered second-rate lands.

The Plains are a comparatively level district, composed of sandy and gravelly loam—the gravel in places [Charity School at Kendall] is one hundred feet deep. Wells have been sunk to the depth of sixty-six feet through fine gravel only [near Richville]. The first settlers of the country relate that these plains were entirely destitute of shrubs or trees, and produced nothing other than some perennial and very hardy annual plants. In 1820 they were covered with "*Scrub Oaks*" from three to five feet in hight. The timber on them now is Aspen, Black Jack Oak, Pin Oak, White Oak, Burr Oak, and Hazel bushes. The farmers could not be induced to purchase any of these lands prior to 1830, at even a slight advance on Government prices. About 1833 a number of Bostonians organized a company at Massillon, Stark county, under the name of the "*Massillon Rolling Mill Company.*" This

Digitized by Google

company purchased many thousands of acres of the "*plains*," cleared off the Scrub and other Oaks, introduced "*bull*" plows, which required three to four yoke of cattle to operate them, through the many roots left in the ground.

To the utter astonishment of all the Pennsylvania "oak-land" farmers, these plains produced abundant crops of most excellent wheat; and many of these "plains" farms are at present among the very best wheat farms in that county.

From all that we have been able to learn of the *Darby Plains* and *Pickaway Plains*, we should not be surprised to learn that they are as good wheat lands as the plains in Stark county.

Speaking of the soils in the United States, Robert Russel says: "In the township of Caledonia (in Western New York), which is chiefly farmed by Scotchmen or their descendants, the soil is light and gravelly, and wide piles of stones lie around the borders of many fields, monuments to the industry of the owners. Notwithstanding appearances, I was told that wheat and clover are as sure crops in that township as in any other within the State; and I can bear testimony that the young layers of clover were truly beautiful. The farmers here, as in Scotland, have learned to judge of the character and quality of the land by the kind of stones that are strewed over it. In the Genessee country, hard and flinty stones are regarded as indicating that the soil is well suited for the production of wheat and clover. Soils which are derived from the boulder clay are capable of growing the largest crops of wheat and barley, but they require a great deal more labor to cultivate them. These clay soils are by no means rich in vegetable mold, but have a fine, healthy red tinge, derived from the oxide of iron, which the eye of practical men look upon as being associated with something that promotes the healthy growth of every crop that is cultivated."

The above indications may be valid for Western New York, but may mislead in Ohio, Indiana, Michigan, or Kentucky.

It may not be inappropriate in this place to present a brief

Digitized by Google

classification of soils, which will in some degree assist in determining the kind of crop to be grown upon it. It is not proposed in this essay to treat of soils in detail, and we shall be content in the chapter on the treatment of soils to confine ourself to a wheat soil only.

CLASSIFICATION OF SOILS.

Sand may contain:

In Small Quantity.
- Silica,
- Oxide of Iron,
- Lime.

Clay may Contain:

In Smaller Quantities.
- Silica,
- Alumina,
- Lime,
- Potash,
- Soda,
- Phosphoric Acid,
- Sulphuric Acid.

Limestone or Calcareous matter may contain:

In Small Quantity.
- Lime,
- Silica,
- Alumina,
- Oxide of Iron,
- Potash,
- Soda,
- Phosphoric Acid,
- Sulphuric Acid.

Organic Matter, or Decaying Vegetable and Animal Matter may contain:

Humus,
Other Vegetable Remains,
Animal Remains.

In Small Quantity, (but in a fine state of division, and well incorporated, the mineral constituents of former generations of vegetables or crops).
- Silica,
- Potash,
- Soda,
- Phosphoric Acid,
- Sulphuric Acid,
- Chlorine.

According to the preponderance of one or more of these compounds, soils are arranged in the following classes: Vegetable molds, clay soils, sandy soils, calcareous soils, marly soils, and loamy soils. Let us now briefly consider the leading character of each of these classes of soils.

Vegetable Molds.—All soils that contain a large quantity of vegetable matter, either in the shape of humus or otherwise, are included in this class. Here we find two distinct

Digitized by Google

varieties of soils, viz., fertile molds and peaty or boggy soils. By a large quantity of vegetable matter is meant more than five or six per cent.,* which is the quantity usually found in ordinary soils. In garden molds there is generally about 9 to 10 per cent. of organic matter; in peaty and boggy soils, often as much as 70 per cent. Hence we see the amount of organic matter is no criterion of fertility. The superior quantity of garden mold, as compared with the soils of our fields, is due not so much to the organic matter or humus it contains, as to its finely-divided and well-worked condition, and to the more complete mixture of its constituents.

In boggy and peaty lands it is this excess of vegetable matter that renders them unproductive. Hence the proper course toward their improvement consists in employing the most efficient means at our disposal for getting rid of, or altering the condition of this vegetable matter; in most cases, burning and the liberal use of lime, will effect this object.

Clay Soils.—Soils of this description are distinguished by their cold, dense qualities, and are well known as "heavy soils," for the reason that the successful cultivation of these soils can only be accomplished by the expenditure of a great amount of labor, strength, and capital. We have already noticed the peculiar retentive quality of clay, and have remarked upon the usefulness of this property of clay. But in soils that consist almost entirely of clay, this quality becomes too much of a good thing, and constitutes the chief obstacle that the tiller of clay soils has to encounter. For this reason, little can be done with clay soils until they are thoroughly drained. Another operation, often found very successful in the reclamation of unproductive clay land, is burning; liming also is a valuable means of bringing into cultivation soils in which an excessive quantity of clay is the cause of infertility. The subsequent treatment in the management of clay soils,

* In stating the quantity of soils, we generally speak of this composition in one hundred parts, or say so much per cent. of a substance.

Digitized by Google

consists in working them in as complete a manner, and as often as the state of the ground will permit.

With a great amount of labor and expense clay soils become exceedingly fertile, and return a good profit to the cultivator, since they require less in the shape of manure than most other kinds of soil. This is because many clays contain inexhaustible quantities of the mineral substances required by plants, and only require proper management to yield these materials in an available form. Hence, clay soils are particularly adapted for the production of grain crops, especially wheat.

Sandy Soils are those that contain from 70 to 90 per cent. of sand. They are distinguished by characters the reverse of those possessed by clay soils. They are light, porous, deficient in retaining moisture; they never suffer from drought, and by heavy rains are deprived of the little valuable matter they may originally contain. The chief defect of these soils is this want of retentiveness which allows the rain and water to wash out the valuable portions of any manure that may have been supplied, before the roots of the plants have had time to take up these substances. Hence the term "hungry" applied by farmers to this sort of soil.

For this reason, if at all practicable, the manure should be added in small and frequent doses. It is for the same reason that the system of liquid manuring succeeds on soils of this description. The improvement of such soils obviously consists in adding clay, marl, etc., if such materials can be procured at a price at all consistent with the benefit they are likely to produce.

Calcareous, or Lime Soils.—This is a most extensive class of soils, including soils of most diversified characters. To this class belong all soils in which carbonate of lime forms the greater part of the bulk, or that contain more than 20 per cent. of lime; but since the rocks from which these soils are formed vary most widely in their composition and physical

Digitized by Google

character, it follows that soils of every degree of fertility are included in this division.

Lime soils are generally light soils, and easy to work; the greater number are poor, thin soils; some of them, however, are exceedingly good soils, and remarkable for their fertility. Lime soils of all descriptions are particularly adapted for the growth of leguminous crops, as clover, peas, etc.

Marly Soils are those that consist of a mixture of clay and lime, and contain from 5 to 20 per cent. of lime, and whose qualities are of course intermediate, between clay and calcareous soils. These soils are subdivided into clay marls, chalk marls, sandy marls, etc. Marls of different kinds are often used as manures, and generally with good results. The effects produced by marls are usually more striking than those which follow the application of other calcareous matters. This superiority is mostly due to the phosphoric acid which many marls contain.

Loamy Soils are intimate mixtures of sand, clay, lime, and organic matter. They are subdivided into clay loam, sandy loam, etc. These are probably the richest sorts of soils, next to the better sorts of vegetable molds. Like vegetable molds, they contain a fair proportion of clay, sand, lime, etc., and the whole in a friable, well-mixed condition; and it is to this fact, that the superior quality of loamy soils is mainly due.

In order to convey a better idea of the composition of soils, we annex the following table, which includes analyses of each class:

Digitized by Google

COMPOSITION OF SOILS.

	A fertile vegetable mold.	A good sandy soil.....	A fertile clay soil.....	A fertile loamy soil.....	A calcareous or lime soil.	A marly soil.....
Organic Matters, Humus, etc.....	10.08	.49	8.88	11.24	6.33	10.50
Oxide of Iron.....	6.30	3.19	8.82	4.87	9.31	11.92
Alumina	9.30	2.65	6.67	14.04		
					Car. lime	
Lime.....	1.01	.24	1.44	.83	54.56	19.92
Magnesia.....	.20	.70	.92	1.02	trace.	.25
Potash	.01	.12	1.48	2.80	1.03	.71
Soda.....		.02	1.08	1.43		
Phosphoric Acid.....	.13	.07	1.51	.24	trace.	.38
Sulphuric Acid.....	.17	trace.	trace.	.09	trace.	.04
Chlorine	.....	trace.	.....	.25	.....	.76
Insoluble Silicates (clay and sand).....	72.80	92.52 (sand.)	72.83	63.19	28.77	55.52
Carbonic Acid and loss..	.....	.....	1.87	.....	.....	.....
	100.00	100.00	100.00	100.00	100.00	100.00

This classification is usually adopted in the description of cultivated soils. The general composition of a soil, and its connection with one or other of the above classes, may in some measure be judged by examining it in the ordinary manner, by its color, texture, the character of the stones it may contain, the quantity of organic matter, etc. But to be able to speak positively on this subject, it is necessary to ascertain the precise composition of the soil. This can only be done by a chemical analysis. It is the business of the analytical chemist to do this in such a manner that each constituent of the soil may be separated, and its proportions determined.

An approximate analysis of this sort is not difficult to make,

Digitized by Google

and might perhaps be performed by any one so disposed; but since a chemical analysis is of very little use unless it is complete, that is to say, unless every thing contained in the soil is separated, and the potash, phosphoric acid, and other more valuable parts of the soil are accurately determined; and as these operations require much care even in the hands of an experienced chemist, we do not think it desirable to describe in any way the process for the chemical analysis of a soil.

Another kind of analysis, often of great service in judging of the capabilities of a soil, is called a mechanical analysis, and requires much less care and accuracy in its performance than a chemical analysis. This kind of analysis has for its object the determination of the relative amount of organic matter, sand, clay, and lime, and in many cases is all that is necessary to decide important questions in the practical management of soils.

The value of chemical analysis in deciding agricultural questions is often very great, and in many cases at once determines whether a proposed scheme for improvement is calculated to succeed or not. For instance, in the important question of subsoiling, we can at once learn whether it is desirable or not to turn up the subsoil, by making a complete analysis of it: from the result of this analysis we can decide whether this admixture with the surface-soil is likely to produce improvement or injury. Subsoils often contain poisonous substances, which, if turned up, will of course exercise an injurious effect upon the surface-soil; on the other hand, valuable fertilizing materials often lie hidden in the subsoil, which might greatly enrich the surface. Again, the infertility of a soil is often explained by an analysis. The soil may be suffering from the want of some material indispensable to the growth of plants, or it may contain something poisonous to plants; in either case chemistry is generally able to enlighten us, and to point out the means for remedying the evil. Of a soil whose fertility is impaired, we can all pronounce that it wants manuring; but with the assistance of an analysis we

Digitized by Google

may also learn in what substance the soil is deficient—or what kind of manure it wants. With this knowledge we may restore its fertility in the most economical manner, by supplying those materials only that are required, and leaving out all the others, in this case useless materials, always present in compound manures. Perhaps the most frequently occurring instance of practical benefit conferred by chemistry upon agriculture, is manifested in the assistance it renders in connection with the question of liming. Chemistry tells us in the readiest manner, whether a soil wants liming or not, and points out the best plan of proceeding if it does. If, as often happens, we have a choice of two or three sorts of lime at our disposal, it will also tell us which sort is likely to produce the best effect. Limestones and marls vary most widely in their fitness for use in this way: many of them contain an excessive amount of magnesia, and on this account are dangerous to use. Others may contain appreciable quantities of the valuable phosphoric acid.

On all these points chemical analysis will enlighten us. We may ascertain in a very ready manner if there is enough lime in a soil as follows: Place a little of the soil in a wineglass, and add some muriatic acid (this acid is well known, and can easily be procured by the name of spirits of salt). If the earth now bubbles up, or effervesces, we may assume that plenty of lime is present in the soil; but if no effect is perceptible, we may infer that the soil is deficient in lime.

The lime in soils usually occurs in the shape of carbonate of lime: this, as we have seen, consists of lime and carbonic acid gas in a fixed or solid state. On adding to this combination muriatic acid, the lime unites with this acid, and liberates its former companion—carbonic acid. This gas, in escaping from the mixture, gives rise to the bubbling up, or effervescence. This test, it must be remembered, is but a very rough one, and by no means conclusive as to the presence or absence of lime in a soil, yet it will often be found useful as a general test for lime.

Digitized by Google

CHAPTER XV.

EXHAUSTION OF SOILS.

THIS chapter is taken entire from Liebig's recent (April 2, 1859), work on Modern Agriculture. It so completely describes the process and rationale of exhaustion, while at the same time it is so very suggestive of the course to be pursued to retain the fertility of the soil, that no abstract, abridgment, or condensation of the original appeared to us satisfactory, and for that reason the chapter is introduced entire.

The experiments of Kuhlmann, Schattenmann, and Lawes, agree in showing, that the salts of ammonia exert a most favorable influence on the evolution of straw and leaves; and if this influence extends in like manner to the underground organs, the roots, then it ought to follow, that the action of ammonia promotes the development of those organs destined for the absorption of food, and that these salts, applied at the proper time increase the number of the leaves and roots.

This circumstance explains the favorable action exercised in spring by ammoniacal manures, while in summer their influence under otherwise similar circumstances is but trifling.

If the plant, in fact, has produced, during the first period of its growth, a sufficient number of leaves and roots, an additional supply of ammonia can be of no great use to its further development, where the other constituents of food in the soil are not deficient; for the leaves can now receive from the air the nitrogenous food necessary to the formation of seeds. In summer there is more watery vapor in the air than in the colder spring; and as the quantity of ammonia in the air, according to the observations of all experimenters, increases with the temperature and moisture, plants must necessarily

Digitized by Google

find more ammonia in the air in summer than in spring. We may as a rule hold, that in the colder seasons of the year, plants are more dependent on a supply of ammonia from the soil, than in the warmer; or in other words, that the employment of nitrogenous manures in spring is most advantageous to plants.

In England and Scotland it is the result of general experience, that the earthy phosphates are not always sufficient for a good and certain crop of turnips. When sown in May they require the addition of a nitrogenous manure, while, if this take place in the middle of June, they thrive generally as well with phosphates alone, as when combined with ammonia.

We can hence tolerably well define the cases in which ammonia is hurtful; for while nitrogenous manures promote the growth of the leafy cabbage, they impede that of the roots of turnips. The latter plant is frequently observed to shoot out only stem and leaves when growing on spots upon which manure heaps have lain. Mangold-wurzel, in a similar case, produces the largest roots. The flowering time of these plants is delayed by this manure.

To produce flowers and seeds, it appears to be a necessary condition in many cases, that the activity of the leaves and roots should reach a certain limit—a period of rest. It is only from this period that the vegetative activity appears to take a decidedly new direction, and that the sap, when no longer required for the production of new leaves and roots, is applied to the formation of flower and seed.

With many plants, want of rain, and of the consequent supply of food, limits the formation of leaves, and promotes the production of flowers. Dry and cool weather hastens the formation of seeds. In warm and moist climates, the cereals, when sown in summer, bear little or no seed; and root crops flower and bear seed more readily on a soil poor in ammonia, than on one rich in this substance.

In the employment of nitrogenous manure, the agriculturist

Digitized by Google

must consequently have distinctly before him the object which he wishes to attain. He must act with plants as with animals. When he wishes to fatten the latter, and at the same time to preserve their health, he gives them daily no more food than they can digest.

Manures must always be of such a nature as to furnish plants with their suitable food at each period of their growth. Plants which have a longer period of vegetation, require consequently no supply, or, at least, a much smaller one of nitrogenous manures than those whose period of existence is short. For such as possess the shortest period of vegetation, and which grow rapidly and with vigor, the concentrated manures are preferable to those which give up their active constituents only slowly. In dry localities, winter wheat thrives after clover without further manuring; while, as a rule, the application of Peruvian guano or Chili-saltpetre (top dressing) is most beneficial to wheat sown in spring.

The continuous cultivation of the same plant on the same field does not necessarily unfit this field for its production, if it is amply provided with the chemical conditions for the growth of the plant, and possesses physical properties of a right kind. If, after the third or fourth year, the plant no longer thrives on such a field, the reason manifestly does not lie in any deficiency of its vital conditions (for we have assumed that these are present), but in the accumulation of causes which injure its healthy growth.

The food of plants consists of chemical compounds, which, in virtue of their chemical properties, produce certain effects on the substance of the cells and the most delicate portions of the frame of the leaves and roots, by which plants appropriate their food. Their chemical action increases with their quantity; and if presented to plants beyond certain limits, they sicken and ultimately die.

In air in which free ammonia is present in excess, even though it be to only a most minute extent, many plants die as if struck with a poisonous blast. Carbonic acid acts in a sim-

Digitized by Google

ilar way, though in a less degree; and weak solutions of free alkalies or alkaline earth and their salts, in a soil, produce the same effects on other plants.

In nature we find a wonderful provision exists in the chemical and physical properties inherent in the soil, for completely obviating the chemical action of the nutritive matters on the absorbent rootlets. Free ammonia, the free alkalies, and alkaline earths, are fixed by the soil, and with their loss of solubility they also lose those chemical properties which are hurtful to plants. Plants can then select what is necessary to their existence, without any hindrance from extraneous influences which may endanger their proper growth.

It is evident that the soil must possess such a neutral chemical character as the most important condition of the healthy structure and functions of the roots. The different species of plants require, however, special conditions for the growth of each. One species requires the constituents of fresh spring water; another flourishes only in bogs; others in carbonaceous and sour soils; others, again, only in ground which abounds in alkaline earths.

By cultivation the character of the soil is modified, not only by the removal in crops of a portion of its active ingredients, but also by the addition to it, by means of many plants, of a greater amount of carbon and nitrogen substances, in the form of the remains of roots. The enrichment of the soil in organic matter appears to be a cause of disease and death to many plants. Clover and many of the turnip tribe will no longer grow on such a soil, and several species of grass quickly disappear from it.

It has been frequently found in England that turnips, when grown on the same field at too short intervals, become subject to a peculiar disease, which manifests itself in an unusual development of the roots. Instead of a round, fleshy head, weighing several pounds, from which filamentous roots spread out into the ground, the tap-root splits into a great number of hard, woody, stem-like roots of the thickness of

Digitized by Google

the finger (finger and toe disease). This disease, which is owing to the peculiar character of the ground, is removed by a large dose of quick-lime. It is certain, however, that the lime does not act in this case, because there was previously a deficiency of it in the soil, for a supply of it to the field at seed time, like other manures, produces no effect, for the latter is apparent only after one or two years. To produce a favorable change in the quality of the field, the lime must manifestly penetrate to a certain depth, and this requires a considerable time. By the simple application of superphosphate of lime, to the complete exclusion of organic manures, Lawes succeeded in raising nine successive crops of turnips on the same land, and in the ninth year obtained 187 cwt. of roots per acre.

Rain water, in slowly filtering through a soil rich in organic matter, extracts a substance which communicates a brown color, and at times an acid reaction to the water. An addition of burnt lime to this soil destroys the solubility of the organic matter in water, and its power of diffusion in the soil. The lime decomposes the organic substances, and by its presence converts the process of putrefaction, which is hurtful to plants, into one of decay which is advantageous to them.

The presence of organic matter in a soil rich in silicates, enables water in percolating through the soil to dissolve a much larger quantity of hydrated silicic acid than is conducive, in many plants, to the process of absorption taking place in the roots. Lime destroys this property, and, by its direct action on the silicate, potash is ultimately set free, and rendered fit for distribution in the soil. Sainfoin continues to flourish on fields rich in lime. It is certain that the presence of the lime in such a soil is not advantageous to this plant, because it requires more lime for its vital purposes than other plants which flourish luxuriantly on land much poorer in lime; but the cause for the necessity of this excess of lime must be sought for in the fact, that it destroys certain

Digitized by Google

injurious matters which gradually accumulate by the continuous growth of this plant on the same soil.

As a matter of course we understand, that, in a number of cases in which the same plant will no longer grow on the same soil, the cause just indicated is not alone in operation, but deficiency of food generally, or in the proper proportions, must be regarded as the proximate cause of the failure. The necessity for taking into consideration so many causes which impede or promote the growth of plants, makes the practice of agriculture one of the most difficult of pursuits.

In fields bearing perennial plants, with roots which penetrate to no great depth, similar injurious matters gradually collect, which are hurtful to the growth of future generations of plants. The irrigation of meadows appears to accomplish the important object among others of removing these injurious matters by the oxygen and by the carbonic acid dissolved in the water, which penetrates the ground, and brings it into a condition similar to that produced by careful ploughing. An analysis of the water flowing from the meadow would probably show that it removes as much mineral matter and ammonia as it brings to it. We do not, of course, here speak of meadows to which liquid manure has been applied, or which have been irrigated with rich sewerage water from towns; for in these cases two causes are in operation to augment the produce, one of which (a supply of mineral food and ammonia) is almost excluded in the case of spring and river water.

The culmiferous, turnip, and tuberous plants which the agriculturist cultivates, comport themselves in a most peculiar manner in the absorption of their mineral food. While sea-plants receive their whole supply of these substances in a state of solution from the surrounding medium, the water which percolates through cultivated soils, brings to the roots of land plants none of the three most important and most essential elements of food, viz., phosphoric acid, potash, and ammonia. Water alone withdraws from the soil none of

Digitized by Google

these substances; their passing into the organism of plants must therefore be directly effected by the organs of absorption in the ground, with the co-operation of water. The roots extract these substances from those portions of the soil, penetrated with water, which are in direct contact with their absorbent surfaces; and such portions of soil must contain the whole quantity necessary for the complete development of the plant, since the roots can receive none of them, except from the particles of earth with which they are directly in contact.

If the food of plants in the soil can not move toward the roots, it is evident that the roots must spread about to look for food.

Plants can not obtain from the soil more food than it contains. Further, its fertility is not to be measured by the whole quantity present in it, but only by that portion of the whole quantity which exists in the smallest particles of the soil. For it is only with such portions that the rootlets can come into close contact.

A piece of bone weighing about 30,000 milligrammes (one ounce) in a cubic foot of earth, produces no marked effect on its fertility. But if these 30,000 milligrammes of phosphate of lime be uniformly distributed throughout the earth, it will suffice for the nourishment of 120 wheat plants. Ten thousand milligrammes of food, having a surface extent of 100 square millimetres, are within the same given time not more effective than ten milligrammes having the same surface extent. Of two fields with the same amount of food, one may be very fertile, and the other equally unfruitful, if the food is more uniformly distributed throughout the former than the latter.

The common plough breaks and turns up the soil without mixing it; it only displaces, to a certain extent, the spots on which plants have already grown. But the spade breaks, turns, and mixes it thoroughly.

A potato, turnip, or wheat plant can not thrive on the spot

Digitized by Google

in which the same kind of plant has grown in the preceding year, if the portions of soil with which the rootlets were in contact, contain no more, or only an insufficient residue of food. The roots of the succeeding plants find in all these spots either no food or only a deficient supply. Every other spot contains more.

As the smallest portions of food can not of themselves leave the spot in which they are held firmly fixed by the soil, we can understand what immense influence must be exerted on its fertility by its careful mechanical division and thorough intermixture.

This is the greatest of all the difficulties which the agriculturist has to overcome.

If a field is to produce a crop corresponding to the *full* amount of food present in it, the first and most important condition for its accomplishment is, that its physical state be such as to permit even the finest rootlets to reach the spots where the food is to be found. The extension of the roots in every direction must not be obstructed by the cohesion of the soil. Plants with thin, delicate roots can not grow on a tenacious, heavy soil, even with abundance of mineral food. These facts explain in a very simple manner, one of the many favorable effects of green manures on such soils, and enable us to understand the reasons of the preference given in many cases, by agriculturists, to fresh over rotten farm-yard manure. The mechanical condition of the ground is, in fact, remarkably altered by the plowing in of plants and their remains. A tenacious soil loses thereby its cohesion; it becomes brittle, and more readily pulverized than by the most careful plowing; and, in a sandy soil, a certain coherence is introduced among its shifting particles. Each stem of the green-manure plants plowed in opens up by its decay a road by which the delicate rootlets of the wheat plant ramify in all directions to seek their food. With the exception of their combustible elements, the ground receives from the green-manure plants nothing which it did not previously contain;

Digitized by Google

and these of themselves would have no effect on the increase of the crop, without the presence in the soil of the necessary mineral food.

None of the three most important constituents of food exists, by itself, in a soluble form in the ground, and none of the means employed by the agriculturist to make them available to his plants, deprives the soil of its power of retaining them; or, if dissolved, of withdrawing them from this solution. The principal end gained by the means he employs is only a uniform distribution of the food throughout the soil, so as to put it within the reach of the roots of his plants.

A 2½ acre field (= 1 million square decimètres) of good wheat soil produces an average crop of 2000 kilo. (= 4411 lbs.) of grain, and 5000 kilo. (= 11,028 lbs.) of straw; the two contain together 250 kilo. (=551 lbs.) of mineral substances. Each square decimètre (= 10,000 square millimètres or 15.5 square inches) of this field yields 250 milligrammes (= 3.85 grains) of ash constituents to the plants growing upon it. Each square millimètre (= .00155 square inch), from the surface downward, must contain a quantity of food corresponding to the wants of each individual rootlet. If the food is wanting in any one particular particle of the soil, then this portion can not contribute to the nourishment of the plant. *The amount of food in each portion of a transverse section of ground, in each square millimetre from the surface downward, is the measure of its capacity for production.* Each rootlet absorbs, according to its diameter, the food with which it comes in contact on its way downward.

If we suppose that the sectional area of the roots of the whole wheat plants which grow on a square decimètre amounts to 100 square millimètres, or that upon the same surface there exists a wheat plant with two or three stems, and with a hundred roots each of a square millimètre sectional area, then must each of these rootlets receive 2½ milligrammes of mineral food in order to supply the plant with 250 milligrammes. Each of the 10,000 square millimètres (= one square deci-

Digitized by Google

mètre), from the surface downward, must contain these 2½ milligrammes; which would give a total quantity of 25,000 milligrammes (= 25 grammes = 386 grains) to the square decimètre, calculated to a depth of 10 inches; or 25,000 kilo. (24½ tons) to the hectare (2½ acres), *i. e.*, somewhat more than ½ per cent. of the whole soil.

A hectare which, from the surface downward, contains no more than 250 kilo. = 550 lbs. of mineral matter (of which 50 kilo. = 110 lbs. are potash, and 25 kilo. = 55 lbs. are phosphoric acid) would, according to this calculation, be completely unsuitable for wheat; for even though each wheat plant possessed, instead of one hundred, one thousand roots, each of the thickness of a hyacinth root, it would nevertheless not be able to receive by these more than a tenth part of its wants from the soil.

According to our assumption, which probably barely reaches the full amount really present, a hectare must contain, from the surface downward, in order to yield an average crop of wheat, at least 5000 kilo. (= 11,000 lbs.) of potash and 2500 kilo. (= 5500 lbs.) phosphoric acid.*

If an average wheat crop of 2000 kilo. (= 4400 lbs.) of grain and 5,000 kilo. of straw, has removed one per cent. of the mineral food from the soil, the latter remains still productive for new wheat crops in the following years; but the amount of produce diminishes.

If the soil has by mechanical means been most carefully mixed, the wheat plants of the second year on the same field will find at each spot one per cent. less food, and the produce

* If the mineral food, so very small in proportion to the whole mass of soil (2 grains in a cubic inch), were present in chemical combination with it, it is impossible to form an idea how it could be distributed in this state everywhere in the soil, so as to be reached by the roots. The comportment of soils of the most different kinds toward solutions of these elements, shows that they are present and fixed in a way somewhat similar to coloring matter in dyed stuffs, or in charcoal which has been used to decolorize a fluid; in these cases a very small quantity in weight is sufficient to cover an extraordinary extent of surface.

Digitized by Google

in corn and straw must in the same proportion be smaller. Under similar conditions of weather, temperature, and fall of rain, only 1980 kilo. (= 4356 lbs.) of grain, and 4950 kilo. (= 10,890 lbs.) of straw, will be reaped in the second year; and in each following year the crop must fall off in a fixed ratio.

If the crop of wheat removed in the first year 250 kilo. (= 550 lbs.) of mineral constituents, and a hectare (2½ acres) of soil to the depth of 12 inches, contained one hundred times this quantity (25,000 kilo., or 24½ tons), there will remain in the soil at the end of thirty years of cultivation, 18,492 kilo. (= 18 tons) of food.

Whatever then may have been the variations in the amount of produce from this field, in the intervening years, caused by different conditions of weather, it is evident, that if there has been no replacement of the mineral matters removed, there can be obtained in the thirty-first year, under the most favorable circumstances, only $\frac{185}{250} = 0.74$, or somewhat less than three-fourths of an average crop.

If these three-fourths of an average crop do not yield to the agriculturist a sufficient excess of income over expenditure, if they merely cover his expenses, then the crop is no longer *remunerative*. He considers the field to be now *exhausted* for wheat crops, although it still contains *seventy-four* times more food than an average crop yearly requires. The effect of the total quantity of the mineral food in the soil has been, that in the first year each root found in those portions of the soil with which it came in contact, the requisite quantity of these substances for its complete development; and the result of the subsequent continuous crops has been, that in the thirty-first year only three-fourths of this quantity is found in these portions.

A field exhausted for wheat cultivation, will produce *remunerative* crops of *rye*.

An average crop of rye (= 1600 kilo., or 3520 lbs. of grain, and 3800 kilo., or 8360 lbs. of straw) extracts from the

Digitized by Google

ground per hectare only 180 kilo. (= 396 lbs.) of mineral matter. Under similar circumstances, one rye plant takes up only 180 milligrammes (= 2.77 grains).

If a soil must contain 25,000 kilo. of mineral matter, in order to produce an average crop of wheat, a soil in which there are only 18,000 kilo. of the same substance, is rich enough for an average crop of rye, and will yield a number of such crops which shall be remunerative.

According to our calculation, a field which is exhausted for the cultivation of wheat, still contains 18,492 kilo. of mineral matter, which in their properties are identical with those required for rye.

If we now inquire, after how many years of continuous rye cultivation will the average crop fall to one of three-fourths the amount, we find—assuming that this amount is no longer remunerative—that after twenty-eight remunerative crops, the field will be exhausted for the cultivation of rye. The mineral matters still remaining in the ground amount, however, to 13,869 kilo. (= 13½ tons).

A field on which rye can no longer be cultivated with profit, is not necessarily unsuitable for oats.

An average crop of oats (2,000 kilo. of grain and 3,000 kilo. of straw per hectare) withdraws from the soil 310 kilo. (= 682 lbs.) of mineral matter, being 60 kilo. (= 132 lbs.) more than a wheat crop, and 130 kilo. (= 286 lbs.) more than a rye crop.

If the absorbent root surface of the oats were the same as that of rye, then oats following rye would not be a remunerative crop; for a soil which furnishes 310 kilo. out of a stock of 13,869 kilo. for a crop of oats, loses thereby 2.23 per cent. of its amount of mineral constituents; while by our calculation the roots of the rye extract only one per cent. This can only happen if the root surface of the oats exceeds that of the rye 2.23 times.

According to the above, the oat crops will exhaust the soil most rapidly. After 12¾ years the return of produce must sink to three-fourths of its original amount.

Digitized by Google

None of all the causes which may diminish or increase the amount of a crop, has any influence on this law of exhaustion of the soil by cultivation. When the sum of the food has reached a certain point of diminution, then the soil ceases to be productive, in an *agricultural sense*, for a cultivated plant. If by incorporating with it atmospheric food, organic materials and salts of ammonia, the produce has been augmented for a number of years, the state of exhaustion will then occur *sooner*. On the other hand, any obstacle to the free absorption of food diminishes the amount of produce, and the limits of exhaustion are consequently reached at a *later* period.

For each cultivated plant there exists a similar law.

This state of exhaustion inevitably happens, even when there has been withdrawn from the soil by a course of crops only one of all the different mineral substances necessary for the nourishment of plants; for the one which is awanting, or exists in deficient quantity, renders all the others inefficient, or deprives them of their activity.

With each crop, each plant, or portion of a plant, taken away from a field, the soil loses a portion of the conditions of its fertility; that is, it loses the power of again producing this crop, plant, or portion of a plant, after the expiration of a number of years of cultivation. A thousand grains of corn require from the soil a thousand times as much phosphoric acid as one grain; and a thousand straws, a thousand times as much silicic acid as one straw; if, therefore, there is a deficiency of a thousandth part of the phosphoric or silicic acid in the soil, then the thousandth grain and straw will not be formed. A single corn straw removed from a cornfield, makes this field bear one corn straw less.

If it is true that the mineral constituents of the culmiferous plants are indispensable for their growth, and must be supplied by the soil, if the plants are to flourish; if it is true that among these mineral matters *potash*, *phosphoric acid*, and *silicic acid*, are not conveyed to the roots in a state of solution, then it necessarily follows that a hectare (2½ acres), contain-

Digitized by Google

ing 25,000 kilo. (= 24½ tons) of the constituents of the ashes of wheat, uniformly distributed through it, and in a state quite fit for assimilation by the roots, can to a certain point yield a series of remunerative crops of different species of straw plants, without any replacement of the minerals removed in the grain and straw, if a uniform state of mixture of the soil has been maintained by careful plowing and other suitable means. The succession of such crops is determined by this, viz., that the plant cultivated the second year shall take away from the soil less than that of the first; or that it contains a greater number of roots, or, in general, a greater absorbent root surface than the first. From the average crop of the first year, there would be a diminution of produce from year to year.

The agriculturist, to whom uniform average crops are exceptions, and varying returns caused by changing states of weather is the rule, would most probably not have noticed this constant diminution, not even though his field had in reality possessed such favorable chemical and physical conditions as to have enabled him to cultivate on it for seventy years successive crops of wheat, rye, and oats, without replacing any of the mineral matters withdrawn from it.

In favorable years, good crops approaching nearly to an average one, would have alternated with bad crops in other years, but the proportion of unfavorable to favorable crops would have constantly increased.

The greater number of European fields under cultivation do not possess the physical character which has been assumed in the case just under consideration.

In most fields all the phosphoric acid necessary for plants is not distributed in the state in which it is readily available to the roots. One portion is simply dispersed throughout it in the form of little granules of apatite only (phosphate of lime), so that even though the soil may altogether contain more than a sufficient proportion, yet in its various portions there may exist in some too much, in others too little, for the

Digitized by Google

wants of plants. The mechanical preparation of the soil would displace these granules, but would not cause their thorough distribution and incorporation with it. To effect this requires the *co-operation of a chemical action.*

After each rye or oat crop there remains in the soil a considerable quantity of roots, which after one or two years entirely disappear. We know that these organic matters have undergone *decay;* that their constituents have united with oxygen; and that the carbon has formed carbonic acid, which has accumulated in the air contained in the porous soil, as analysis shows us.

When rain falls on this soil, it dissolves the carbonic acid, which thereby acquires the power of taking up phosphate of lime. This carbonic acid water does not withdraw from the soil the phosphate of lime contained in it, but wherever it meets with the granules of apatite or phosphorite, it dissolves a certain portion; for in these granules there exists no cause of resistance to the action of the water; and except the cohesion between its own particles, no other extraneous influence prevents its solubility in water.

Under these circumstances, a solution of phosphate of lime must consequently be formed, which spreads in all directions around each granule. Wherever this solution comes in contact with soil not already saturated with phosphate of lime, the soil will take up and retain a certain portion of this salt. *The portion of soil now saturated with phosphate* will oppose no further obstacle to the wider diffusion of the solution.

The same process is found to take place in the diffusion of the silicic acid and potash in the soil, when the latter contains silicates which can be decomposed by carbonic acid. There is then formed around each particle of silicate a solution of silicate of potash, the constituents of which are always again fixed, in the first place by the nearest lying, and then by the more remote portions of the soil.

A certain time is required for the distribution of the food throughout the soil in the manner above described.

Digitized by Google

If we suppose that our field had contained 25,000 kilo. of the ash-constituents of wheat, distributed in the most uniform manner through it; and in addition to this, but *unequally distributed*, five, ten, or more thousand pounds of the same food, the phosphoric acid as *apatite*, the *silicic acid* and potash as easily decomposed silicates;—if we further suppose that every two years a certain quantity of the last-named substances had been rendered soluble, and capable of distribution in the soil in the manner above mentioned, and in such proportions that the roots should have found every where in the soil these elements of food in the same proportions as in preceding years of cultivation—a sufficient amount, therefore, for a full average crop; then should we, under these circumstances, have obtained during a series of years *full* average crops, *if we had interposed a year of fallow between each year of cultivation.* Instead of thirty constantly-diminishing crops, we should in this case have obtained, during a period of sixty years, thirty *full* average crops, if the additional portion of minerals in the soil had proved sufficient during that time to replace every where the phosphoric and silicic acids, and the potash, removed annually by the crops. With the exhaustion of the additional proportion of minerals in our field, the period of diminishing crops would commence; and *the further interposition from this time of fallow years would not then exercise the slightest influence on the increase of produce.*

In the case under consideration, had the supposed additional quantity of phosphoric and silicic acids, and potash, not been *unequally* but *uniformly* distributed throughout the field, and *every where completely accessible* to the roots of plants, and in a state fit for absorption, then *thirty full* crops would have been reaped in thirty successive years, *without the interposition of a year of fallow.*

Let us return to our field, in which we assumed that there were 25,000 kilo. of ash constituents of wheat, thoroughly dispersed throughout it, and in a state fit for absorption, and that it was sown each year with wheat; let us now suppose

Digitized by Google

that in each crop the ears only were cut from the straw, and that the entire straw was left on the field and immediately plowed in; then must the loss of minerals be less in this year than before, for all the constituents of the straw and the leaves have remained in the ground; we have only removed from the field the mineral constituents of the grain.

Among the substances which the *straw* and *leaves* have obtained from the soil, are found all the constituents of the *seed*, but only in altered proportions. If we express by the number 3, the whole phosphoric acid removed by the grain and straw together, the loss would be represented by the number 2, if the straw remains in the ground. The *decrease* of produce in a field in a succeeding year bears always a definite proportion to the *loss* of mineral substances by the preceding crop. The following crop of grain will be a little larger than it would have been, had the straw not been left in the ground. The produce of straw will be nearly the same as in the preceding year, for the conditions for the formation of straw have been but slightly altered.

By thus taking *less* from the field than formerly, we thereby increase the number of remunerative crops, or in other words, the total amount of grain produced in the whole series of corn crops. A portion of the straw-constituents is converted into corn-constituents, and in this form is now removed from the soil. The period of exhaustion will *always* come, but under these circumstances it occurs at a *later* date. The conditions for the production of grain go on constantly decreasing, for the minerals removed by it have not been replaced.

This relation would still have remained the same, had the cut straw been carted about the field, or been plowed in after serving for litter to cattle. What has been supplied to the field in this way, had been originally taken from it, and can not therefore *enrich* it. When we reflect that the combustible elements of straw are not furnished by the ground, it is clear that in leaving the straw in the ground, we really leave only the constituents of its ash. The field was thereby enabled to

Digitized by Google

yield a little more than it otherwise would have done, simply because less had been taken from it.

Had we also along with the straw plowed in the grain or its ash-constituents; or instead of the wheat grain returned to the field a corresponding quantity of another seed, rape-dust (that is, rape-seed freed from its fatty oil), which contains the same ash-constituents, the composition of the soil would have remained the same as before, and the same amount of produce would have been obtained as in the preceding year.

If after each crop, the straw is always returned in this manner to the field, the further result then is, an inequality in the composition of the active constituents of the soil.

We have assumed that our field contained the mineral matters of the whole wheat plant in the right proportions for the formation of straw, leaves and grain. By leaving the straw-constituents in the soil, while those of the grain were constantly removed, an increase of the former took place, when compared with the proportion of grain-constituents still remaining in the field. The field retained its productiveness for straw, but the conditions for the formation of grain decreased.

The consequence of this inequality is an unequal development of the whole plant. So long as the soil contained and supplied, in the proper proportions, all the necessary mineral matters for the uniform growth of all parts of the plant, the *quality* of the seed and the proportion between straw and grain in the diminishing crops remained uniform and unaltered. But in proportion as the conditions for the formation of straw and leaves became more favorable, so did the *quality of the seed deteriorate* as its quantity diminished. The sign of this inequality in the composition of the soil, as a consequence of cultivation, is the diminution in weight of the bushel of corn. While at first a certain portion of the constituents of the returned straw (phosphoric acid, potash, magnesia) was expended in the formation of grain, at a later period the reverse of this takes place, and demands are then

Digitized by Google

made on the grain-constituents (phosphoric acid, potash, magnesia) for the formation of straw. We may imagine that when there exists in a field this inequality in the conditions for the formation of grain and straw, a culmiferous plant may, under conditions of temperature and weather favorable for the production of leaves, yield an enormous crop of straw with empty ears.

Vine-dressers and gardeners prune trees and vines in order to obtain larger fruit and in greater quantity, by thus limiting the formation of twigs and leaves; and in many districts, as in Lower Bavaria, it is often considered advantageous to cut down or feed off the corn when half grown. It is found that by this proceeding a larger amount and a *better* quality of grain are obtained. In tropical regions many culmiferous plants bear no seed, or but a small quantity, because the soil does not contain the proper proportion of conditions for the formation of seed and leaf.

The size of the seed in many plants, is in inverse proportion to the development of the leaf. Tobacco, poppy, and clover have proportionably smaller seeds than the culmiferous plants.

The agriculturist can influence the direction of the vegetative force only through the soil; that is, through the proportion of the elements of food which he supplies to it. *For the production of the largest crop of grain it is requisite that the soil contain a preponderating proportion of food necessary for the formation of seeds.* For *turnips*, *leafy* and *tuberous* plants, this condition is reversed.

An average crop of turnips with leaves contains five times, a clover or potato crop twice, as much potash as the grain and straw of a wheat crop from an equal surface. A clover and a potato crop together remove from two fields of a hectare each, as much phosphoric acid as the grain of three wheat crops from three fields of the same size.

It is therefore evident, if we cultivate potatoes and clover on our field which contains 25,000 kilo. of the mineral constitu-

Digitized by Google

ents of wheat, and remove the whole produce of tubers and clover, that we withdraw from the soil of these two fields as much phosphoric acid, and three times as much potash, as by three wheat crops. It is certain, that this removal from the soil, by another plant, of these important mineral substances, produces a great effect on its fertility for wheat; the yield and the number of the wheat crops diminish.

If, on the other hand, during a period of two years, we had cultivated on the field, wheat in the first year, and potatoes in the second, and had plowed in the whole of the potato crop and the wheat straw, and had continued to do this for sixty years, we should not by these means have in the least degree altered or augmented the produce in grain, which the field was capable of yielding. The field has neither *acquired* nor *lost* anything by the cultivation of potatoes, for these were always left in the field. When the grain crops taken from the field have diminished the store of mineral matters to $\frac{3}{4}$ of their original quantity, then this field ceases to furnish a remunerative crop, if $\frac{3}{4}$ of an average return no longer yield any profit to the agriculturist. We arrive at the same results, if, instead of potatoes, we had interposed crops of clover, and had in the same way each year plowed it in. We have assumed that the physical condition of the soil was most favorable, and consequently, could not be improved by incorporating with it the organic matters of the clover and potatoes. Even had we removed the potatoes from the field, mown and dried the clover, and then carted the potatoes and hay back to the field, or made them first pass through the cattle stalls, or made any other use of them; had we in this way returned to the field the whole sum of mineral matters in both crops, we should not by all these operations have produced from it in thirty, sixty, or seventy years, a single grain more than would have been obtained without all these changes. During this whole period the conditions for the production of grain have not increased, but the cause of decrease in the crops has remained the same.

Digitized by Google

The plowing in of the potatoes and clover could produce a beneficial effect only on those fields, in which a favorable physical state did not exist; or in which the mineral matter was unequally distributed, and was partly inaccessible to the roots of plants. But an action of this kind is just the same as that of green manuring, or of one or more years of fallow.

By the incorporation with the soil of the clover and organic substances, the amount of decaying matters and of nitrogen in it is increased from year to year. All that these plants received from the atmosphere remained in the ground, but the enriching of the soil with these otherwise useful matters can not effect the production of more grain than formerly; for this depends on the proportion of the minerals in the soil, and these have not been increased, but on the contrary, have constantly decreased, in consequence of the removal of the corn. By the increase of nitrogen, and of decaying organic matter in the soil, the produce might possibly be augmented for a number of years, but the period at which such land would no longer produce a remunerative crop, occurs in such circumstances only so much the more quickly.

If we cultivate on three different wheat fields respectively, wheat, potatoes, and clover, and plows all the potatoes and clover yielded by the other two into the wheat field, from which the grain alone is removed, we shall by these means render the latter more fertile than before, for we have enriched it by the whole amount of minerals which the potatoes and clover had extracted from the other two fields. It has received three times as much phosphoric acid, and twenty times as much potash, as the grain has carried away.

This wheat field will now be able to produce in three successive years, three full grain crops; for the conditions for the production of straw have remained unchanged, while those for corn have been increased threefold. If the agriculturist in this manner raises in three years as much corn as he would have done in five on the same fields, without the

Digitized by Google

co-operation of the mineral constituents of the clover and potatoes, *then has his profit now evidently become greater*, for he has reaped with the seed for *three* crops as much as he would have done in the other case, with the seed for *five*. But the other two fields have lost in fertility as much as the wheat field has gained; and the final result is, that *with less cost of cultivation and with more profit* than before, the agriculturist has in his three fields anticipated *the period of exhaustion* which would inevitably have overtaken them by the continued withdrawal in grain of the mineral constituents of the soil.

The last case that we have to consider is, when the agriculturist, instead of potatoes and clover, cultivates turnips and lucerne, which, by means of their long and deep penetrating roots, extract a large quantity of mineral matter from the subsoil, which is not reached by the greater number of the roots of the cereals. Where the fields possess a subsoil, favorable to the growth of these plants, we double, as it were, the extent of surface capable of cultivation. If the roots of these plants received the half of their mineral matters from the subsoil, and the other half from the arable soil, the latter will lose by the crops only half so much as they would have done, had the *whole* of the mineral food for these crops been obtained from the arable soil alone.

The subsoil, considered in the light of a field apart from the arable soil, thus furnishes to the turnip and lucerne crops, a certain quantity of mineral matter. If we suppose that in harvest the whole of the turnip and lucerne crops had been plowed under in the wheat-field, which had yielded an average crop of grain, and in this way as much and more mineral matter had been returned than the grain had removed; then by these means, this wheat-field *can be maintained at the same degree of fertility at the expense of the subsoil, just so long as the latter continues productive for turnips and lucerne.*

But since turnips and lucerne require for their growth a

Digitized by Google

very large quantity of mineral matter, the subsoil will be the sooner exhausted, in proportion to the smaller quantity of these substances it contains. Now, as the subsoil is not in reality separated from the arable soil, but lies beneath it, it can scarcely receive back any of the substances it has lost, because the arable soil retains that portion of them which has been added to it. It is only that part of the potash, ammonia, phosphoric, and silicic acids, which has not been taken up and fixed by the surface soil that can penetrate to the subsoil.

By the cultivation of these deep-rooting plants, superabundance of food can consequently be obtained for all those which derive their nourishment chiefly from the surface soil. This supply will not, however, be of any duration; for, in a comparatively short time, many fields will cease to produce these plants, because the subsoil is exhausted, and its fertility is only restored with difficulty. In the first place, lucerne no longer grows, and turnips are only now produced in so far as they are able to obtain their full supply of minerals from the surface soil. Potatoes, which derive their supplies from the upper layers of the surface soil, endure the longest.

The quantity of food which a plant receives from the ground is not alone dependent on the quantity which is present in the finest particles of the surface soil, but also on the number of organs which extract this food from the ground. Two roots will obtain twice as much as one.

The crop is partly dependent on the first root formation.

A grain of wheat or barley contains within itself so large a quantity of food, that it stands in no need of the soil in the first period of its growth. The seeds of these plants when simply moistened, produce ten or more rootlets from six to eight lines in length. The heavier the grain, the stronger and more vigorous is the formation of roots. The seed corn, without receiving any thing from the ground, extends in all directions its organs of absorption, by which it procures its

Digitized by Google

food from a comparatively great distance. Hence the agriculturist attaches great importance to the careful selection of seed.

Small seeds, such as those of tobacco, poppy, and clover, require a richer or more thoroughly prepared surface soil, to prevent the loss of a large proportion; because the soil in the immediate neighborhood of the seed must at once supply it with food after germination. Hence, as the agriculturists say, such plants are more difficult to raise.

The seeds of the cereals may be compared to a hen's egg, which contains within itself all the necessary elements for the development of the young animal. Husbandry would certainly assume quite another form, if for every single cereal plant, as many seeds should be lost, as is the case with poppies, tobacco, and even clover.

The quantity of food which a plant obtains from one and the same soil is in proportion to its absorbent root surface. Of two species of plants which require the same quantity and a similar relation of mineral food, the one with double extent of root surface takes up double the quantity of food.

If it is true that the constituents of the ash of plants are indispensable to their life and growth, it is evident that whatever else may exert a favorable influence on their growth, must be *subordinate to the law*, that the soil, in order to be fertile in an agricultural sense for a cultivated plant, must contain the constituents of the ash in sufficient quantity, and in a state the most suitable for absorption.

The agriculturist has to do with the soil alone; it is only through it that he is able to exercise an immediate influence on plants. The attainment of all his objects in the most complete and profitable manner, pre-supposes the exact knowledge of the effective chemical conditions for the life of plants in the soil; it further pre-supposes, perfect acquaintance with the food of plants, and the source from which it is derived, as well as with the means for rendering the soil suitable for

Digitized by Google

their nutrition, combined with experience and skill in employing them in the proper way, and at the right time.

It is evident from the above statement that the cultivation of plants tends to drain or to render a fertile soil unproductive. In the produce of his fields, destined for the food of man and beasts, the agriculturist sends away that portion of the active ingredients of his soil which contributes to the growth of this very produce. The fertility of his fields continuously diminishes, whatever may be the plants he cultivates or the rotation he adopts. The export of his produce is nothing else than a spoliation of his soil of the conditions for its reproduction.

A field is not exhausted for corn, clover, tobacco, and turnips, so long as it still yields remunerative crops *without requiring restoration* of the minerals which are removed. *It is exhausted* from the moment that the hand of man is needed to restore it to the failing conditions of its fertility. *The great majority of our cultivated fields are in this sense exhausted.*

The life of men, of animals, and of plants, is connected in the closest manner with the return of all the conditions which promote the vital process. The soil by its constituents contributes to the life of plants; its continuous fertility is inconceivable and impossible without the return of those conditions which have rendered it productive.

The mightiest stream, which sets in motion thousands of mills and machines, fails, if the streams and brooks run dry which supply it with water; and these streams and brooks in their turn dry up, if the myriads of little drops of which they consist do not return in the form of rain to those spots from which they have their source.

A field which has lost its fertility by the successive cultivation of different plants, acquires by the application of *farm-yard manure*, the power of producing a new series of crops of the same plants.

But what is *farm-yard manure*, and whence is its origin?

Digitized by Google

The land of the husbandman is the source of all this manure. Manure consists of the straw which has served for litter, of the remains of plants, and of the fluid and solid excrement of man and animals. The excrement is derived from the food.

In the bread which a man daily receives, he consumes the ash-constituents of the seeds of the cereals whose flour has served for the preparation of the bread; in flesh, the ash-constituents of flesh.

The flesh of herbivorous animals, as well as its ash constituents, are derived from plants. These ash-constituents are identical with those of the seeds of leguminous plants; so that if a whole animal were burnt, the residual ash would not differ from that of beans, peas, and lentils.

In bread and flesh, man consequently consumes the mineral matters of seeds, or of the constituents of seeds, which the agriculturist obtains from his land in the form of flesh.

But a very small fraction of the large amount of mineral substances received by man in his food during a lifetime remains in his body. The body of an adult does not increase in weight from day to day; it therefore follows, that all the constituents of his food have passed again completely out of his body. Chemical analysis demonstrates that the ash of bread and of flesh exists in his excrement very nearly in the same quantity as in his food. The comportment of the food in his body is just the same as if it had been burnt in a furnace. The urine contains the soluble, and the fæces the insoluble mineral matters; the bad smelling ingredients are the smoke and soot of an incomplete combustion. With these are also mingled the undigested and indigestible remains of food.

The excrement of swine fed on potatoes contains the ash-constituents of potatoes; that of the horse, the mineral matters of hay and oats; that of cattle, the ash of turnips, clover, etc., which have served for their food. Farm-yard manure consists of a mixture of all these excrements together.

Digitized by Google

By farm-yard manure, the fertility of a field which has been exhausted by cultivation, is completely restored. This is a fact which the experience of thousands of years has established. In farm-yard manure the field receives a certain quantity of organic, that is, combustible matter, and the ash-constituents of the consumed food. We have now to consider what part was played by the organic and inorganic matter in this restoration of fertility.

The most superficial examination of a cultivated field shows, that all the combustible matter of plants which are reaped from the field are derived *from the air, and not from the soil.*

If the carbon of only a portion of the vegetable matter in the crop were derived from the soil, it is perfectly clear, that if the latter contained at first a certain amount of this element before the harvest, this quantity must become smaller after each crop. A soil poor in organic matter would be less productive than one in which it is abundant.

Observation, however, shows, that a field under continued cultivation does not in consequence become poorer in organic or combustible matter. The soil of a meadow, which during ten years has yielded a thousand cwt. of hay per hectare, is not, after this period, poorer, but richer in organic substances. A clover field, after a crop, retains in the roots remaining in the soil more organic matter, and more nitrogen than it originally possessed; but it has become unproductive for clover, and yields no longer a remunerative crop.

A wheat or potato field is in like manner, after a crop, not poorer than before in organic matter. *In general the soil is enriched by cultivation with combustible constituents, but its fertility nevertheless steadily diminishes.* After a number of consecutive remunerating crops of corn, turnips and clover, these plants are found to flourish no longer on the same soil.

Since, then, the presence of decaying organic matter in a soil, does not in the slightest degree retard or arrest its exhaustion by cultivation, it is impossible that an increase of these substances can restore the lost capacity for production.

Digitized by Google

In fact by incorporating with the soil of a field completely exhausted, boiled saw-dust, or salts of ammonia, or both together, we can not restore to it the power of yielding a second or third time the same series of crops. If these substances improve the physical character of the soil, they will exercise a favorable influence on the produce; but after all, their action still consists in accelerating the exhaustion, and rendering it more complete.

Farm-yard manure, however, restores thoroughly the power of producing the same series of crops, a second, third, or a hundred times. It arrests fully, according to the quantity employed, the state of exhaustion; its application may render a field more fertile; in many cases more so than it ever has been.

The restoration of fertility by farm-yard manure can not have been caused by the presence of combustible matters (carbonaceous and nitrogenous substances). If these produced any good effects, they were of a subordinate nature. *The action of farm-yard manure depends most undoubtedly on the amount of the incombustible ash-constituents of plants in it, and is determined by these.*

In the farm-yard manure the field received back in fact a certain quantity of all the minerals which had been withdrawn by the crops. The decrease in its fertility stood in exact relation with the *removal* and the restoration of the fertility with the *restitution* of these mineral substances.

The incombustible elements of cultivated plants do not of *themselves* return to the soil like the combustible in the atmospheric sea from which they are derived. By the hand of man alone are the conditions of the life of plants given back to the soil. By farm-yard manure, in which these conditions are fulfilled, the agriculturist, as if by a law of nature, restores to his field its lost powers of production.

A rational practice maintains the circulation of all the conditions of life; and empirical practice breaks the chain which binds man to his home, by robbing the soil of one con-

Digitized by Google

dition after another of its fertility. Though the empiric knows that the soil is different to-day from what it was yesterday, he nevertheless believes that it will be to-morrow what it is to-day. *Founding on the experience of yesterday*, he teaches that the fertile soil is *inexhaustible;* but science, guided by *laws*, shows that the productiveness even of the most fertile soil, has its end, and that the very soil which appears inexhaustible, *is exhausted.* Because nature was kind and gave abundantly to the father, the empiric thinks that the son may also take abundantly and without any care for the future. On the fact that man has a home, and that the spot of earth, from which he toils with the sweat of his brow to gain his subsistence, is his home, depends the development of the human race. The continuance of his existence in his home is dependent on the law, that *force is expended by use and maintained by supply.*

[We add a paper on that particular modification of Tull's method of wheat cultivation, which is due to the Rev. S. Smith, of Lois-Weedon, Northamptonshire, England, in order to prove that the great thing to be done in farming is to pulverize the soil—that a poor soil well pulverized is as productive as a good soil indifferently managed. That the principles of Tull were sound, as far as they went, there is now no reason to question. But because they halted when they should have gone forward, and because the details of the practice which Tull found indispensable for duly carrying his principles out, were a bar to the attainment of such an amount of produce as would satisfy the just demands of the farmer, his special husbandry for the growth of wheat, with the exception of a few experiments here and there, soon died away. For, a close and careful examination of the only continuous and authenticated balance sheets which are in existence, of average crops of wheat grown on Tull's plan, or on any modification of it, by his best disciples, such as De Chateauvieux and Du Hamel, or in the clever experiments in Yorkshire, reported in the Ap-

Digitized by Google

pendix to Mill's Husbandry, will discover a result of less than sixteen bushels per acre, while the blind and unauthorized reliance of that system on organic food alone, for the support of the plant, must have led, more or less speedily, to utter exhaustion of the land and total failure. The broad distinction, then, between Tull's system of growing wheat and that proposed by Mr. Smith, and carried out at Lois-Weedon, is this, that by certain alterations in practice, the latter has, without manure, raised the average produce from sixteen to thirty-four, and that he is enabled, by the principles on which that change of practice is founded, to insure on wheat lands, that is, on the great majority of clay and heavy loam, a sufficiency of every element of fertility, inorganic as well as organic, for an indefinite succession of wheat crops on the same acre of land.

The process by which the scheme is carried out, is a very simple one, and is given in detail in his pamphlet, entitled "A Word in Season, or How to Grow Wheat with Profit." Briefly, it is this: "I divide my field," says the author, "into lands five feet wide, in the center of each land I drop or drill my seed in triple rows, one foot apart, thus leaving a fallow interval of three feet between each triple row. When the plant is up I trench the intervals with a fork, easily taking my spits about three inches from the wheat, and at spring and during summer, I clean them with the blades of the sharp cutting-horse hoe, and keep them open with the tines of scuffles. Every year, in fact, I trench and cultivate two and a half feet out of the five for the succeeding crop, and leave the other two and a half for that which is growing. One moiety of each acre is thus in fallow, and the other moiety wheat, and the average yield is thirty-four bushels, grown without difficulty or danger in the execution, and surpassing the yield of a whole acre on the common plan. It will here be seen at a glance how I differ from Tull in practice; how the fork takes the place of the plow, and does better work on a narrower compass; how the fallow is reduced from four-fifths of the

Digitized by Google

land to only one-half, and how in consequence the produce is more than doubled at once."

With regard to the number of rows of wheat, Tull ended with two. "Upon experience," he says, "I find the double row much preferable to the triple." The principal reason for this preference was, that he found the middle row inferior to the outside rows, which stood nearer to the pulverized intervals; and, certainly, on Tull's plan, the middle row always will be inferior, for his rule was never to go below the staple. And so, in some slight degree, will it be at the outset on Mr. Smith's plan, till the soil is not only dug but pulverized from fourteen to twenty inches deep; because till then the roots of the middle row are unable, with ease, to reach the intervals, after passing beneath the roots of the outer rows. Accomplish that depth, and there will be no difference between them. So Mr. Smith has found it, in his early piece of deep-tilled wheat, and so Tull asserts in his 11th chapter: "Where any inner or middle row has a competent number of plants, standing on a competent thickness of sufficiently pulverized earth, and its outside row the same, whereunto the hoe-plow has gone deep and very neat, such middle rows equal the outside row. But where any of these circumstances are wanting, the middle row falls short more or less, in proportion as more or fewer of them are wanting." The reasons against only two rows, according to Mr. Smith, are, that without the "alloy" of the middle row they would become too luxuriant from excess of food, and especially because the more frequent recurrence of the fallow interval would, in all probability, greatly reduce the bulk of the crop. In favor of the double row, is the greater ease with which the growing crop can be cleaned.

Such, in brief, are the details of the practice at Lois-Weedon; and considered only as mere mechanical operations on the soil, they are perfect in their tendency to promote healthy vegetation in the plant. But, while the free exposure of the rows to the influence of the sun and air is thus emi-

Digitized by Google

nently conducive to the health and vigor of each separate plant, and while this process of disintegration of the clods of the earth enables the roots to penetrate the soil with ease, in search of their food, the fallow intervals brought into this state of cultivation are actually providing the food itself. For it does not appear to admit of a doubt, in the present state of chemical investigation and analysis, that, supposing the staple of wheat land—the clay and loamy soils spoken of by Mr. Smith—to be exhausted, there is underneath the staple, in the subsoil of such land, a supply of inorganic food for the plant, which, even at a depth easily attainable by the implement of cultivation, is practicably inexhaustible.

Bring up by degrees, then, a portion of this subsoil as it is required; bring up before winter, and lay rough on the surface, just so much, and so much only, as can be decomposed and mellowed by the annual alternate fallow, and the process will render soluble a supply of mineral substances adequate to the demand of each alternate crop. Nor does it now seem doubted that the atmosphere contains a sufficiency of every organic ingredient which is required by the wheat plant. And here again, is displayed that harmony which runs through and accompanies each process of the plan. For when the clay or loamy soil has thus been deepened and pulverized, and so far enriched, it is filtered for its other important office; it has become a retentive absorbent of the riches of the atmosphere, which drop unrepelled into its bosom, and are there reserved, either for the use of the growing plant, or to accumulate for the succeeding crop. There are yet other collateral advantages, of great and acknowledged importance, attending this pulverized depth of soil between the rows of the growing wheat. For in the driest season, it holds a never-failing supply of necessary moisture for the plant, and in the wettest year it enables all injurious moisture to filter and drain away. The result of this scheme of wheat-growing has been an average produce of about thirty-four bushels per acre, dating back from this present July, 1854; the scheme was com-

Digitized by Google

menced, between nine and ten years ago, with hand-labor, alone, on a small portion of a field, under all the disadvantages of being fresh broken up. For so far from that being a profitable condition for land in wheat—on this plan at least—it is positively injurious, tending, as it does, to over-luxuriance, and its frequently fatal effect. For the first five years the average outlay was as follows:

One double digging,	£1 10 0
Two single diggings,	1 00 0
Pressing, sowing, hoeing, carrying, thrashing, rates and taxes,	2 6 0
Two pecks of seed,	0 2 6
Rent,	2 0 0
Outlay,	£6 18 6

Of the first year's produce and profit no account was taken; but for the following years the average yield was thirty-four bushels.

34 bushels of wheat (40s.),	£8 10 0
1 ton 12 cwt. of straw (40s.),	3 4 0
Produce,	£11 14 0
Deduct outlay,	6 18 6
Net profit with wheat at 40s.,	£5 0 6.

This straw is introduced into the account, since it is clearly as much the produce of the soil as the grain itself. And it is charged as profit, because on this plan—unlike the ordinary mode of farming—it is not returned to the wheat field in the shape of manure. As a question beyond a doubt, therefore, the produce of the straw is to be taken like the grain, and charged at its value. "That value to myself is clear," says the author, "for I purchase straw, and charge for it at the price I give. The value also to my neighbor who farms on my plan, is clear, for he sells it. The value to others will vary; but take the judgment of any three intelligent farmers: tell them their opinion will be published, and their names

Digitized by Google

given; and when they have well considered its use, either as chaff or as litter, and then manure, it will be found, I apprehend, that their decision as to its value, to those good farmers who do not sell their straw, will differ but little from those who do."

This, then, was the first stage of the scheme, when all the operations on the land were performed by hand-labor alone. But it was objected that, however successful this plan of growing wheat might be, it was only success on a very small scale; and that the plan, therefore, was valueless as a model for the farmer. It was objected, too, that as the crops were taken from land lately brought under tillage, as a criterion of the plan, they were inapplicable and useless. But, if Mr. Smith's principles are sound, the latter objection is evidently futile. For if the subsoil of wheat land contain an inexhaustible supply of inorganic food, and the atmosphere provides a sufficiency of organic matter for the wheat plant, nothing more is required. Nay, if the land be full of nourishment in itself, and to this be added that competent and continuous provision from above, the fear is, in reality, surfeit and sickness to the crop from over-feeding. In common farming, what is more difficult in the growth of wheat than to hit the point between parsimony and profusion? And, with our variable climate, how true to general experience are the telling words of our cautious and far-seeing instructor in agriculture, that "if wheat be over-fed in a wet season, it goes down, or in a dry, cold May, it is mildewed?" "Last August (1849)," says Mr. Pusey, "I observed beyond mistake, on a close examination, that the better the land the more the wheat was mildewed; the better farmed was the same land, the more was it also mildewed."

In order, however, to try the soundness of the two objections referred to, and to put them to the intelligible and unerring test of practice, the author states that he took in hand a four-acre field, exactly suited to his purpose: for it was what is usually deemed exhausted. It had never known a

Digitized by Google

bare fallow in the memory of man. Four years before it had been manured for Swedes, which were carted off the land. It had no dressing for the three following crops, the rotation having ended with a crop of wheat sown broadcast. In this condition, the stubble standing, he entered upon the field in October, 1850. He then simply plowed the field an inch deeper than it had ever been plowed before, cleaned and leveled it, and so without further preparation, got in his seed. After this, on the first appearance of the plant above ground, he sent in his spadesman to trench the intervals two shallow spits deep, for a fallow for the succeeding crop. The produce from the four acres was twenty-one and a half quarters of Bristol red wheat; and when it had been disposed of, the result in outlay and profit, with wheat at 40s., was found to be this:

Paid for plowing (6s. the half portion of each of the four acres),	£ 1	4	0
Harrowing, leveling, and cleaning the foul stubble (10s. ditto),	2	0	0
Pressing the channels for the seed (1s.),	0	4	0
Dropping the seed into the channels by hand (5s.),	1	0	0
Four pecks and one gallon of seed (5s. per bushel),	0	5	7½
Rolling (6d.),	0	2	0
Hoeing between the rows (3s.), scarifying the intervals (3s.), bird-keeping (4s.),	2	0	0
Reaping (9s.), carrying to barn and unloading (6s.),	3	0	0
Thrashing and winnowing 20½ quarters (at 2s. 11½d.),	8	0	0½
Rates and taxes (4s. 8d.), and interest on £20, for outlay, implements, etc.,	1	18	8
Total outlay,	£14	14	6
20½ quarters of clean wheat (40s.),	£35	17	6
8 tons of straw (40s.),	16	0	0
Gross produce,	£51	17	6
Deduct outlay,	14	14	6
Total amount of profit to proprietor,	£37	3	0.

Digitized by Google

"The result, then," says the author, "may be stated thus: One moiety of each of these four acres in wheat, and the other moiety fallow—the land exhausted—no manure—little more than a peck of seeds to each half acre—and yet the yield 20½ quarters. I very respectfully ask the farmer's attention to these facts; and would bid him reflect, that there is nothing whatever in the operations which were so successful here, to prevent their application elsewhere."

This is the second stage of the scheme, in which the greater economy of horse-power is introduced, and the hand-labor confined to the usual hoeings and the trenching before winter. For hand-labor can not be dispensed with altogether at present; since no implement *at present* can trench. Nothing but the spade or the fork has yet been found able, within the limited space of thirty inches, to turn up the subsoil from the required depth, and place it uppermost, in such a form as to receive the full benefit of the frosts of winter and the scorchings of summer; that exposure of the subsoil is indispensable, providing as it does the necessary and never-failing supply of inorganic manure for the wheat crop.

There is yet a third stage in prospect to accomplish the digging and the burning up of the subsoil by machinery. This would certainly increase the profits of the scheme, by reducing very considerably the expense of cultivation, and would relieve the mind from the fear of the want of hands; a fear, however, not entertained by the author himself, though many alluring outlets have been opened for the superabundant labor of the country.

After the foregoing statement, little need be said of the profitableness of the scheme itself: for if out of an arable farm of 400 acres, 100 acres be set apart for wheat on this plan, and, with wheat at 40s., the profits of these 100 acres, at a gain of £5 per acre net, be £500 to the renting farmer, the thing speaks for itself.

The remaining 300 acres—supposing them to be farmed on the common plan of rotations—would tell their own tale, and

Digitized by Google

if they told it truly, they could scarcely be silent on the subject of that unneed straw from the 100 acres of wheat. The advantage of having on the spot say 150 tons of straw, although accounted for at its value, would be acknowledged by them at once.

Such is the profitable scheme of wheat-growing proposed by Mr. Smith, and carried out at Lois-Weedon; but, eminently profitable as it is, it is quite clear from the details, that very great nicety of cultivation is required in order to insure success. So precise, in fact, are the conditions, that on the first two years of trial, in various parts of the country, several signal failures have taken place. To say, however, that much care, and much attention, and much energy, are all in requisition here, is only to assert a recognized law of nature, that nothing eminently good is ever attained but by strenuous exertion. To pulverize the trenched soil, to keep it clean, to sow early, are all indispensable to entire success; and it is unfortunate that the two untoward seasons during which these two successful trials were made, were less dusty, more uncleanly, and less fitted for early sowing, than were probably ever known in the memory of man. Still there were some experimenters who, bad as was the sticking place, screwed their courage to it, and did not fail, and the author of the scheme declares, with the utmost sincerity, that "he never knew an unsuccessful case where he knew the conditions of the scheme had been strictly carried out."]

Digitized by Google

CHAPTER XVI.

MANAGEMENT OF SOILS.

THERE is no doubt that the culture of wheat is annually becoming more and more precarious in Ohio. Notwithstanding there are great improvements made in agricultural implements and machinery, and these generally well distributed throughout the State; yet the products per acre, do not increase in proportion to the amount expended for machinery and labor. It is evident then that our soils are manifesting indications of less fertility than in former years. The great question in Ohio is what shall be done to retain even the present condition or state of fertility, and if possible increase it? The man who will furnish to the farmers in Ohio a practical solution of this problem—who will inform them how it may be accomplished, by incurring a very slight expense, or such expenditure as the small farmers can readily afford, may well be regarded as a benefactor to our agricultural community.

It is by no means certain that farmers always select the lands best adapted to the growth of wheat, for the culture of that plant. Instances are not wanting where the attempt has been made for a number of successive years to grow wheat, on soils not adapted to it. The attempts have invariably resulted in disappointment to the grower.

Soils of a medium quality should be selected. Those which are too rich, such as the black mold, or black sandy soils of the river and creek banks, or low places, should never be selected for wheat. They are unquestionably better adapted for corn and potatoes. The soils on "bottom lands" as they are generally termed, consist in too great a degree of organic matter—of humus, and decaying or decayed vegetable

Digitized by Google

matter, to grow wheat to any advantage to the grower. They lack the proper *earthy* materials, or if they possess them, they are not in a proper chemical condition for the purposes of the plant. It is a generally admitted fact, that on such soils the wheat grows very rank, producing straw of enormous growth, but the heads are invariably small, even of the best varieties of wheat, and produce very few and indifferent grains of wheat. Aside from this, wheat grown on low places is more liable to suffer from frosts, mildew, rust and insects, than that grown upon higher grounds; it is also as a general thing much more liable to fall or lodge than that on more elevated places.

The best lands for wheat are those in which the principal ingredient is clay,—either red, yellow or white, of which the white however, is always the poorest. There is no doubt that more labor must be expended on a *pure* clay soil than on almost any other; yet when properly managed it yields more uniformly, and yields larger crops of wheat than any other soil. The first thing to be done after clearing a piece of clay soil, is, to have it thoroughly drained, before it is "broke up." Clay retains more moisture than any other kind of soil; but when it loses its moisture, it becomes drier and harder than any other. A new clay will shrink or contract fully one sixth in sun-drying or "baking"; it is easy to imagine what effect this shrinkage will have upon the tender rootlets of the plants.

Lime in considerable quantities should be applied on new clay lands, to neutralize the excess of acidity with which they are almost universally impregnated. Straw, or barn-yard manure can not be too plentifully plowed in, on such lands—not for the purpose of acting as manures, but as a means of converting the clay into a loam. Lime, straw, or barn-yard manure if plentifully applied, will also prevent the soil from baking, because the introduction of any foreign substance between the particles of clay prevents the latter from cohering. It is very evident that the oftener the soil is stirred, the more

Digitized by Google

reduced in size will the particles become. If a piece of new ground is plowed four times in succession, it is reasonable to suppose that the particles of its soil are four times as much reduced, and that barn-yard manure or straw is four times as thoroughly incorporated as that which has been plowed once only.

The Roman farmers in olden times plowed their wheat lands from six to eight times before seeding, and they seldom or never failed in being fully rewarded by the more abundant crop for their additional labor. Tradition says that the ancient Egyptians seldom or never plowed their wheat lands less than six times.

It is very evident that every time the earth is broken by any sort of tillage, new surfaces of the soil become exposed, not only to the atmosphere, but to the action of the roots of the plant. Now it is this new surface from which the plant obtains or elaborates its food, as is proved by the fact that no plant will grow in precisely the same place where a similar plant grew before. In a peach orchard, the old trees were removed and young ones put in the precise spot occupied by the old ones—they died in the third year, apparently without cause; but when planted on the intermediate spaces, between the old trees, they grew luxuriantly, and bore excellent crops of fruit. Twenty successive good crops of wheat *may* be grown on the same soil, "*provided always*," as the attorneys say, that each new crop has new surfaces of soil to act upon. This fact was well understood by Jethro Tull, more than one hundred years ago. Mr. Tull was the inventor of the *first* drill, and one part of his work is a treatise on making and using *drills* and *plows*, and *horse hoes*.

In his chapter on "Tillage" he says:

"Tillage is beneficial to all sorts of land. Light land being naturally hollow, has larger pores, which are the cause of its lightness. This, when it is by any means sufficiently divided, the parts being brought nearer together, becomes for a time, bulk for bulk heavier, *i. e.*, the same quantity will be

Digitized by Google

contained in less room, and so is made to partake of the nature and benefits of strong land, viz., to keep out too much heat and cold, and the like.

"But strong land being naturally less porous, is made for a time lighter (as well as richer) by a good division; the separation of its parts makes it more porous, and causes it to take up more room than it does in its natural state, and then it partakes of all the benefits of lighter land. When strong land is plowed, and not sufficiently, so that the parts remain gross, it is said to be rough, and it has not the benefit of tillage; because most of the artificial pores (or interstices) are too large, and then it partakes of the inconveniences of the hollow land untilled. For when the light land is plowed but once, that is not sufficient to diminish its natural hollowness (or pores) and for want of more tillage, the parts into which it is divided by that once (or perhaps twice) plowing, remain too large, and consequently the artificial pores are large also, and in that respect are like the ill-tilled strong land. Light land having naturally less internal superficies, seems to require the more tillage or manure to enrich it. * * * * Artificial pores can not be too small, because the roots may the more easily enter the earth that has them, quite contrary to natural pores; for these may be and generally are, too small and too hard for the entrance of all weak roots, and for the free entrance of strong roots. Insufficient tillage leaves strong land with its natural pores too small, and its artificial ones too large. It leaves light land with its natural and artificial pores both too large. Pores that are too small in hard ground, will not easily permit roots to enter them. Pores that are too large in any sort of land, can be of little other use to roots, but only to give them passage to other cavities more proper for them, and if in any place they lie open to the air, they are dried up and spoiled before they reach them. For fibrous roots can take in no nourishment from any cavity, unless they come into contact with, and press against all the superficies of that cavity which includes them; for it dispenses the food

Digitized by Google

to their lacteals by such pressure only. But a fibrous root is not so pressed by the superficies of a cavity whose diameter is greater than that of the root.

"The surfaces of great clods form declivities on every side of them, and large cavities, which are as sinks to convey what rain and dew bring too quickly downward to below the plowed part. The first and second plowings with common plows scarcely deserve the name of tillage; they rather serve to prepare the land for tillage. The third and fourth, and every subsequent plowing, may be of more benefit and less expense than any of the preceding ones; for the finer the land is made by tillage, the richer it will become, and the more plants it will maintain. It has often been observed, that when part of a ground has been better tilled than the rest, and the whole ground constantly managed alike, afterward for six or seven years successively, this part that was but once better tilled always produced a better crop than the rest, and the difference remained very visible every harvest. One part being once made finer, the dews did more enrich it; for they penetrate within, and beyond the superficies whereto the roots are able to enter. The fine parts of the earth are impregnated throughout their whole substance with some of the riches carried in by the dews, and there deposited, until, by new tillage, the insides of those fine parts become superficies; and as the corn drains them they are again supplied as before; but the rough large parts can not have that benefit; the dews not penetrating to their centers, they remain poor."

It must be obvious to every one that a finely comminuted seed-bed will produce much more thrifty plants than a coarsely comminuted one will. For this reason when lands are plowed when not too wet, they always produce better than wet plowed ones. A garden deeply spaded and finely worked always produces better than a shallow, cloddy one.

If an entire field for wheat could be as finely comminuted in its particles as a garden the product would astonish the proprietor.

Digitized by Google

All soils have what is termed "*capillary attraction*," that is, the power to suck up, or elevate to the surface mineral matters in solution from the subsoil, and the finer the soil is pulverized the stronger is the capillary attraction. In proof of this position the following, from the pen of J. H. Salisbury, an agricultural chemist of New York State, is here inserted:

"From numerous observations which have been made at different times on the peculiar appearance of the surface of soils, clays, etc., during the warm summer months, and the fact that they, when covered with boards, stones, or other materials, so as to prevent them from supporting vegetation, become in a comparatively short time much more productive than the adjacent uncovered soil; we have been led to the belief that the soil possessed some power within itself, aside from the roots of plants, of elevating soluble materials from deep sources to the surface.*

"To throw some light upon the subject, in May, 1852, I sunk three boxes into the soil—one 40 inches deep, another 28 inches deep, and a third 16 inches deep. All three of the boxes were 16 inches square. I then placed in the bottom of each box three pounds of sulphate of magnesia. The soil which was to be placed in the boxes above the sulphate of magnesia, was then thoroughly mixed, so as to be uniform throughout.

"The boxes were then filled with it. This was done on the 25th of May, 1852. After the boxes were filled, a sample of soil was taken from each box, and the percentage of magnesia which it contained accurately determined. On the 28th of June another sample of surface soil was taken from each box, and the percentage of magnesia carefully obtained as before.

"The result in each case pointed out clearly a marked in-

* Dr. Alex. H. Stephens, of New York, was, I think, the first to suggest this idea. He speaks of it in his address, delivered before the State Agricultural Society of New York, on the *Food of Plants*, in January, 1848. No accurate experiments were performed, however, to fix it with a degree of certainty, till these were made which appear in this paper.

Digitized by Google

crease of magnesia. On the 17th of July, a sample of surface soil was taken a third time from each box, and carefully examined for magnesia; its percentage was found to be very perceptibly greater than on the 28th of the preceding month. On the 15th of the months of August and September following, similar examinations severally were made, with the same evident gradual increase of the magnesia in the surface soil.

"The following are the results as obtained:

	Percentage of Magnesia.		
	Box 40 in. deep.	Box 28 in. deep.	Box 16 in. deep.
May 25th	0.18	0.18	0.18
June 28th	0.25	0.30	0.32
July 17th	0.42	0.46	0.47
August 15th	0.47	0.53	0.54
September 15th	0.51	0.58	0.61

"Before the middle of October, when it was intended to make another observation, the fall rains and frosts had commenced; on this account, the observations were discontinued. The elevation of the magnesia, as shown in the above experiments, evidently depends upon a well-known and common property of matter, viz., the attraction of solids for liquids, or what is commonly denominated capillary attraction. This may be clearly illustrated by taking a series of small capillary glass tubes, and insert one extremity of them in a solution of sulphate of magnesia or chloride of ammonium, and break or cut off the upper extremities just below the hight to which the solution rises. Expose them to the sun's rays; the water of the solution evaporates, and the fixed sulphate of magnesia will be deposited just on the upper extremity of the tube. As the solution evaporates, more of it rises up from below, keeping the tubes constantly full; yet no sulphate of magnesia passes off: it all, or nearly all, remains at, or rises just above, the evaporating surface. Just so in the soil; as the water evaporates from the surface, more water, impregnated with the soluble materials from below, rises up to supply its place. As

Digitized by Google

this evaporation goes on, it leaves the fixed materials behind in the surface soil at the several points of evaporation.

"This explains why we often find, during the months of July, August, and September, a crust of soluble salts covering the surface of clay deposits which are highly impregnated with the alkalies, or any of the soluble compounds of the metals, earths, or alkaline earths. Also the reason in many instances of the incrustations upon rocks that are porous and contain soluble materials. It also helps to explain the reason why manures, when applied for a short or longer time upon the surface of soil, penetrate to so slight a depth. Every agriculturist is acquainted with the fact that the soil directly under his barn-yard, two feet below the surface (that is, any soil of ordinary fineness), is quite as poor as that covered with boards or otherwise, two feet below the surface in his meadow; the former having been for years directly under a manure heap, while the latter, perhaps, has never had barn-yard manure within many rods of it.

"The former has really been sending its soluble materials up to the manure and surface soil; the latter to the surface soil and the vegetation near or upon it, if uncovered.

"The capillary attraction must vary very much in different soils; that is, some have the power of elevating soluble materials to the surface from much deeper sources than others. The pores or interstices in the soil correspond to capillary tubes; the less the diameter of the pores or tubes, the higher the materials are elevated. Hence one very important consideration to the agriculturist, when he wishes nature to aid him in keeping his soil fertile, is to secure soil in a fine state of mechanical division, and of a highly retentive nature.

"Nothing is more common than to see soils retain their fertility with the annual addition of much less manure than certain others. In fact, a given quantity of manure on the former, will seem to maintain their fertility for several years; while the latter, with a similar addition, quite lose the good effects of the manure in a single season.

Digitized by Google

"The former soils have invariably the rocks, minerals, etc., which compose them in a fine state of division; while the latter have their particles more or less coarse."

The great desideratum, then, is, to find some method by which the soil may be as perfectly pulverized or comminuted as may be. When a field has been pastured during several years the surface becomes very compact, from its natural "settlings," as well as from the trampling of cattle, and when broken up by the plow the furrow slices are little else than parallelograms of earth inverted from their former position. Many fields of this description which the writer has seen present an appearance very like the annexed cut (Fig. 20), the furrow slices turning over in many instances several rods in length, without a single break in them. Such lands should be plowed, cross-plowed and replowed at least, before being seeded in wheat. The soil is more coherent, from the roots of grasses and from the trampling of cattle, than that of fallow fields, consequently requires more labor to comminute it.

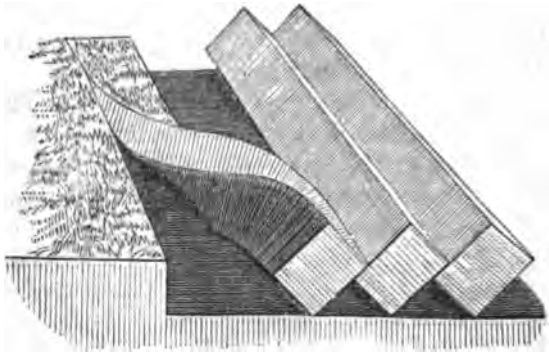


FIG. 20.

The soil of a stubble field, when plowed with the ordinary plow, presents an appearance as in the subjoined cut (Fig. 21). In this it will be observed that the furrow slice crumbles as it is turned over, and although three plowings would be highly advantageous to such soil, yet, if plowed and cross-

Digitized by Google

plowed only, will yield as much as a pasture plowed three times—other things being equal.

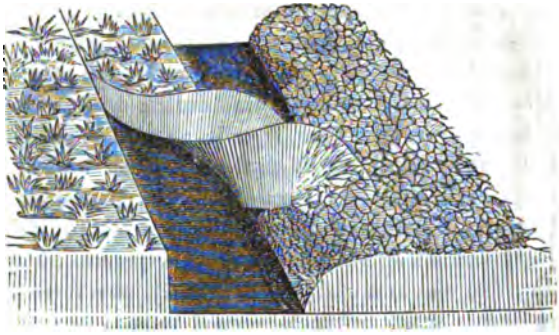


FIG. 21.

But the most effective soil-comminuter which the writer has yet seen in the shape of a plow, is the Columbus Double Plow, a representation of which will be found on the opposite page. The work done by this plow is illustrated in the annexed cut. A furrow measuring from seven to eleven inches deep, and from seven to fifteen wide, can be plowed with it with a draft of from five to seven hundred pounds.

The forward, or skim plow, turns from two to three inches of the sod in the bottom of the furrow; then the after-plow raises and turns from five to seven inches of the under soil on top, entirely covering the sod and all herbage. The roots of the grass being removed by the small plow, the under soil is pulverized by the large one, thus leaving a perfect seed bed, and rendering the use of the harrow unnecessary.

Fig. 23 shows the movement of the furrow slices of sod and sub-soil as turned by the Columbus Double Plow. The Double Plow requires no more draft than the single plow doing the same amount of work. This has been proven by repeated experiments with the dynamometer.

It is, therefore, a desirable implement for deep tilling, as it can be used with two small horses, by plowing a narrow and deep furrow. This is apparent, as will be perceived, that the

Digitized by Google

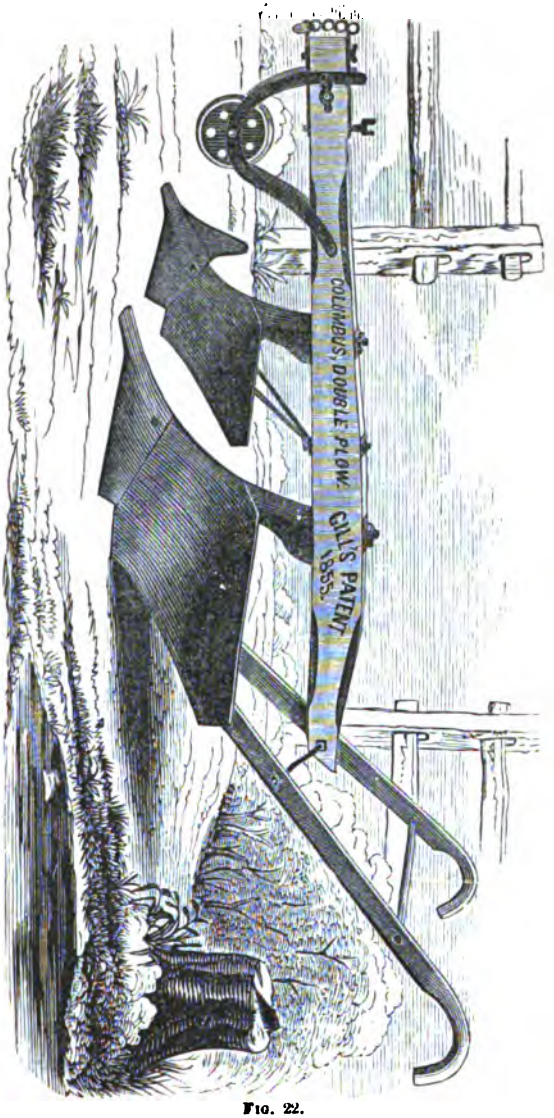


FIG. 22.

Digitized by Google

proportions of the furrow of the important plow (*i. e.* the sod or forward plow) are not destroyed, the width being double or greater than double the depth.

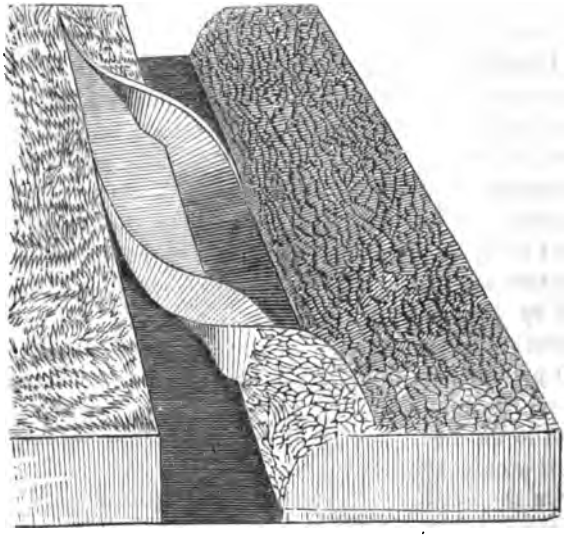


FIG. 23.

DEEP PLOWING.—The objects gained by deep plowing are more numerous than most persons are aware of, especially those who have not given the subject a careful examination.

In the first place, the primary object of all tillage or mechanical division of the soil, is to give the roots of plants a larger range in search of food; and when we consider the extent to which the roots of many plants penetrate the earth, if not obstructed by a compact subsoil, the object gained by deep plowing must be obviously great, even in this respect.

2. By deep plowing, means are afforded to the surplus waters to retreat beneath the surface of the earth, and thus their injurious effects to the growing plants are entirely obviated, while it affords a reservoir of moisture acceptable to the plants in time of drouth.

Digitized by Google

3. The atmosphere is at all times more or less charged with carbonic acid and ammonia, elements of vital importance to the growing crops, which are brought down by showers of rain, and if allowed to penetrate the earth, are deposited in the soil, but if left upon the surface, do not benefit the crop.

4. In times of drouth, when every facility should be afforded to the crop to obtain moisture from light showers and dews, it is only the deep mellow soil that receives the benefits of these agents; for when the showers and dews are deposited upon the compact earth, they are immediately taken up by the atmosphere and lost to the plant; while on the other hand, if the soil is open and porous, they are absorbed by the soil for the future use of the plants. This principle can easily be tested by any one. Examine, in a dry time, a soil of say four inches deep, covering a hard pan or subsoil, and you will find it perfectly dry down the whole depth of the four inches; while on the same soil, in the same location, where the soil is worked to the depth of eight inches or two feet, you will find it moist even to the very surface.

5. On the principle of radiation, deep plowing has decided advantages over shallow, in protecting the crops against frost as well as drouth; for the more compact a substance is, the greater the powers of radiation, consequently it sooner parts with its heat and is reduced to the temperature of the atmosphere, which is frequently below the freezing point, when the loose mellow soil is far above it.

6. On rolling lands, much injury is done by surface washing. Often more of the soluble elements dissolved by showers, are carried into the streams to enrich some ranker plantation, or lost forever in the ocean, than is taken up by the plant; the remedy for which is found only in artificial means, such as deep tillage, trenching, ditching, etc.

Now, when we consider the advantages deep tillage has over shallow, our only wonder is that it is not more generally adopted.

Line upon line and precept upon precept seems so necessary

Digitized by Google

upon this important subject, that no further apology should be required for the amount of space devoted to it in this work. Professor J. J. Mapes, who has paid much attention to *practical* as well as scientific agriculture, presents the following arguments in favor of deep plowing:

"1. All plants consist of three parts—the main stem and its branches; the leaves whose office is to collect the principal *food* or nourishment from the air; and the roots which collect water-sap from the ground to keep the plant moist, to supply its juices, and to act as a vehicle for carrying to different parts of the plant the food gathered by the leaves. The roots also serve as supports to hold the plant in its place.

2. The roots take in whatever liquids they are brought in contact with. They are increased in size and number by the direct application to them of food or stimulants (manures). They are also injured by coming in contact with such soluble poisonous materials as they can absorb.

3. *The contact of air is necessary to destroy (oxidize) certain poisonous mineral salts found in all soils—particularly the proto-salts of iron.*

Now, then, suppose we have a soil from which the air has been shut out by its compactness, or by the constant pressure of water or moisture in its pores. To break up and pulverize such a soil deeply, is to invite the growth of roots downward *below the usual access of air.* These deeper penetrating roots then absorb some of the poisonous (unoxidized) mineral compounds. The consequence is, the structure, not only of the roots, but of the whole plant, is injured. On such a soil it very often happens that shallow plowing, which only disturbs the thin surface portion immediately in contact with the air, will be preferable for the time being, to go down deeply at once. The true way is to go only half an inch to an inch deeper every year, and bring up a little of the under soil in contact with air, to be fitted by it for use; but not bring up enough to injure the growing crops. Every one must have observed that the soil thrown out of a deep well will at first

Digitized by Google

grow nothing; and yet after contact with the air for a year or two, or more, it becomes quite equal to the old surface soil.

Let us now look at another class of soils—those which are open, porous, and by reason of good natural under-drainage are a part of the year free from standing water to the depth of a foot or more. In this case the air will have penetrated deeply, and destroyed poisonous mineral compounds. Deep plowing will not loosen a mass of dangerous material, but on the contrary, will invite down the roots of plants where they will find a supply of moisture, even when the surface is parched with drought. To stir such soil only at the surface, would tend to a shallow growth of roots, and when the surface dries up, the plant fails to get moisture enough to supply the waste of water by evaporation from the leaves. In soils of this character it is manifestly desirable, nay, important, to plow deeply.

It is owing to such diversity of condition in soils, that practical men, reasoning only from their own experience, have been led to exactly opposite views in regard to deep and shallow plowing. Literally, what is one man's meat is another's poison. And this remark has a wider application than to the mere question of plowing. The manures appropriate to particular soils, differ as widely as does the treatment required. Quacks in medicine recommend one kind of pills as a cure for all kinds of disease. Quacks in agriculture, in like manner, prescribe a particular treatment or manure as just the thing for all soils, and if ingenious, they can make out plausible arguments to support their pretensions.

In regard to plowing deeply, the true theory is to provide a deep thorough drainage for all soils not naturally dry to a considerable depth from the surface; and then, *by degrees*, break up the sub-soil, until a deep bed of dry, warm, air-exposed soil is secured. When this is done, plants will send down and spread widely a mass of roots that will support a corresponding growth of vegetation above the surface, and as

Digitized by Google

berore remarked, our crops will be independent of the mere surface effects of drought or rains."

Mr. Henry Stephens, a reliable English agricultural writer, in his treatise on "*Yester Deep Land Culture*," says:

"The great object attained by deep-stirring the subsoil, is the prevention of water lodging about or near the roots of the cultivated plants. It is feared that thorough-draining a clayey subsoil will not alone secure that object. The reason why it is desirable that the subsoil about and below the roots of plants should be in as loose a state as to allow the rain-water that descends from the surface to pass from them quickly, is that the passage of water has a consolidating effect upon the subsoil as well as the soil; and if it do not usually pass quickly through the former, as it does through the latter, it is because the upper soil is always in a loose state by cultivation. Now, there is no way of rendering the subsoil entirely loose but by deep-stirring it. The least consolidation of the subsoil tends to retain the water as it descends from the surface, and thorough-draining can not of itself prevent that tendency in clay subsoils; and water when retarded is sure to chill the roots of plants in winter, and to prevent the incorporation of vegetable matters with both the subsoil and soil; whereas deeply stirring the subsoil renders consolidation impossible for a considerable time, and in the meanwhile the plants enjoy vigorous health by their roots absorbing as much moisture, as it descends past them, as they require, and partaking of as much food as is prepared for them by the natural action of the soil and manure. No fear need be entertained of rendering the soil or the subsoil too dry by means of thorough draining, or in conjunction with it of subsoil trench plowing, inasmuch as the bottoms of all the drains, and the subsoil for several inches above the tiles, are receptacles of moisture, which they are ever ready to yield to the wants of vegetation whenever demanded, through the easy and quick instrumentality of capillary attraction. Shallow plowed land has not a

Digitized by Google

sufficient body of pulverized mold to induce the action of capillary attraction. Continuous shallow plowing has, moreover, the effect of encrusting with a hard stratum the bottom of the furrow in clay subsoils; and those plows which work at a constantly equal depth by means of wheels, render the bottom of the furrow on clay subsoils sooner hard than any other class of plows.

Of all classes of subsoils the sandy ones are most quickly affected by subsoil trench plowing, and they are also as easily consolidated by water. Gravelly subsoils are next most easily affected; and there are such of this class of subsoils so firmly compacted together, without the means of a clayey matrix, that water passes with difficulty through them; and yet, when once broken asunder by the subsoil trench plow, they remain loose ever after. Thin clay subsoils are the next most easily affected by subsoil trench plowing; and generally having small veins of sand traversing them, or small stony grits interspersed through them, they become loose for a considerable time after being subsoil trench plowed. The pure clay subsoils are the longest in being affected by subsoil trench plowing, and they have a constant tendency toward reconsolidation.

It thus being a paramount object with the farmer to have the subsoils of the different classes of soils upon his farm always in a pulverized state, he should make himself well acquainted with the periods when it is necessary to renew their subsoil trench plowing. Experience has not yet decided on the respective periods at which this operation should be renewed on the different classes of subsoils; but enough has been ascertained on this point to lay it down as a rule, that the Double plow should be employed to cross-plow in the autumn the stubble land intended for green crop in the ensuing season, to the depth of 15 inches, at the end of every rotation of fives. The subsoil trench plow will not probably require to be used again during the currency of a lease on sandy and gravelly subsoils, nor even on thin clays; but on pure clays it may be required oftener than once in the course

Digitized by Google

of a lease, although probably no farmer will undertake to do it oftener than once in a lease. The same feeling will probably guide the farmer in the use of these implements that guides him in the liming of a farm—once in a lease. Experience, of course, will determine its frequency; but common sense already instructs that subsoil-trench-plowing will be executed much more easily, more quickly, and therefore less expensively, on repetition than at first.

To demonstrate that deep tillage is not a matter of mere opinion or speculation, the annexed is quoted; being the results produced by systematic deep culture by the Marquess of Tweeddale, in East Lothian, Scotland:

RESULTS OF THE YESTER DEEP LAND-CULTURE ON THE YESTER FARMS.—A few instances of the crops received from each of the Yester farms since it has been treated in the way above described, will suffice to show the results which have already been obtained from the system of deep land-culture here recommended for general adoption by practical agriculturists, whether proprietors or farmers.

It is right to mention that at Yester Mains and Broadwoodside the subsoil-trench-plowing, in a few of the strong clay fields, had an evident injurious effect upon the barley crop and new grass, on account of the subsoil being originally a very bad, poor clay; and the crop of turnips not having been carried off, but eaten on the land late in spring, the seed furrow was obliged to be given when the soil was in an unfit state for plowing, particularly under the circumstance of the large quantity of the subsoil not being thoroughly incorporated with the surface soil. This inconvenience has now been entirely avoided by storing the turnips when at maturity in autumn, and by immediately plowing up the land and exposing it to the frosts of winter.

In the second rotation, now being pursued on Yester Mains, purple-top yellow turnips were raised in 1854, on Steel's Walls field, with 13 loads of farm-yard dung and 2½ cwt. of guano per imperial acre. The crop was 32½ tons per acre,

Digitized by Google

rooted and shawed, as ascertained by measurement and weight from a whole acre of a fair average of the field, when carried off to be consumed by cattle. In this field of 37 acres there is now no trace of the original state of the very bad subsoil to the depth under culture. Barley will succeed the turnips in 1855. Black vegetable matter obtained from the drained loch at Danskine has been put on the strongest clayey spots of fields of this farm to open the tenacity of the clay, and good turnips have been by that means raised upon parts upon which turnips would formerly scarcely braird.

The Moss Bents field, which had originally been stiff clay, containing 15¾ imperial acres, was in oats in 1850, which produced 29¼ bushels the acre. It was bare-fallowed and subsoil-trench-plowed in 1851, and in 1852 produced 61 quarters of good wheat, and 2½ quarters of light, equal to 38½ bushels, and realized above £11 the acre.

The Long Bents field, of sandy clay soil and subsoil, containing 16 acres, was in oats in 1848, which produced 65 quarters, equal to 37 bushels the acre. In 1849 it was bare-fallowed and subsoil-trench-plowed, and in 1850 it yielded 58 quarters of good wheat, and 4 quarters of light, realizing £10 an acre. In 1851 it was in grass, and in 1852 the lea was deep-plowed with the Tweeddale plow 15 inches deep. In 1853 it was in oats, which produced 104½ quarters, equal to 61¼ bushels the acre. In 1854 it carried an excellent crop of turnips, the weight of which was not ascertained.

At Broadwoodside the subsoil-trench-plowing was carried on in a perfect state from the commencement of the improvements.

The Wa' Tree Park, which was originally of stiff tenacious clay soil and subsoil, containing 19¾ imperial acres, was in oats in 1850, which yielded 60 quarters, equal to 28¾ bushels the acre. In 1851, 6¼ acres were bare-fallowed and subsoil-trench-plowed, and 13½ acres subsoil-trench-plowed and made with turnips. In 1852 the 6¼ acres produced, of wheat, 28½ quarters of good, and 3½ quarters of light, realising £15, 7s.

Digitized by Google

4d. the acre; and the 13½ acres produced barley, which averaged 31¼ bushels, and realized £6, 0s. 10d. the acre.

The Holmes Park, which was originally of very poor stiff tenacious clay soil and subsoil, and containing 24 acres imperial, was in grass in 1850, and was deep-plowed, 15 inches, with the Tweeddale plow in winter. It carried oats in 1851, which yielded 108 quarters, equal to 43½ bushels the acre. In 1852 it was subsoil-trench-plowed 19 inches deep for turnips, which were a fair crop. In 1853 it was barley, of which 79½ quarters were good and 18 quarters light, equal to 39 bushels, realizing £9, 17s. 6d. the acre.

The Kitchen Croft, which was originally of stiff sandy clay soil and subsoil, containing a large number of boulders, and consisting of 8¼ acres imperial, was previously let at £8, 15s. for the field, and it was thorough-drained in the winter of 1848. In 1849 it was bare-fallowed and subsoil-trench-plowed 19 inches deep. In 1850 it carried wheat, of which 24 quarters were good, 5¼ quarters light, equal to 34½ bushels, and realizing £8, 8s. 8d. the acre. In 1851 it was turnips, which were good. In 1852, barley, of which 40 quarters were good and 3¼ quarters light, equal to 53 bushels the acre, and was sold for £10, 12s. 10d. the acre.

The land on Broadwoodside farm was limed after being thorough-drained and subsoil-trench-plowed. At first, the quantity used was 48 bolls, or 288 bushels, to the imperial acre; but it was soon found that 30 bolls, or 144 bushels, had an equally good effect upon the land, and that was the quantity which the farm mostly received.

The land on Danskine farm was not subsoil-trench-plowed at all, and only deep-plowed with the Tweeddale plow, with three horses yoked abreast in the compensation swing-trees, to the depth of 14 or 15 inches, as the subsoil was of such an open nature as not to require further pulverization. Sandy oats were the kind first used on this farm, but were given up for the Hopetoun variety, in consequence of the yield being greater and the straw better on the improved soil.

Digitized by Google

The poor clay soil of Danskine was covered with a black vegetable matter, obtained from the bottom of the Loch of Danskine after the water had been drained off. This vegetable substance was laid on the land, at the rate of 180 cubic yards per imperial acre, upon the stubble in autumn, cut small with the spade, spread, and plowed in with a 14-inch furrow with three horses in the Tweeddale plow. At first the quantity laid on was 120 cubic yards the acre, but latterly it was increased to 180. Such a large quantity of matter literally covers the surface when spread over it, so that its black color imparts a darkened hue to the soil after incorporation with it. The cost of digging this matter—lifting it out of the bog by means of a railroad and steam-power, carting it on the land, spreading it, with tear and wear of machinery, and interest on cost of machinery—is 7d. per cubic yard; so that the cost of manuring an imperial acre with it was from £3, 10s. to £5, 5s.

This black vegetable matter is not a peat, but a deposit composed of sphagnum moss, rushes, hazel, alder, willow, in leaves and twigs. Its constituents were ascertained by Dr. Anderson in 1850, viz:

	One specimen.	Another specimen.
Water,	31.78	49.49
Nitrogen,	0.89	0.85
Humine,	6.00	16.82

in the dry state, after exposure to the air. The constituents are valuable on account of the nitrogen they contain, which is 1.5 per cent. in the dry state, and 0.9 per cent. in the state examined, which was of course drier than when taken out of the deposit. This substance was used to act mechanically upon poor thin clay; but after an incorporation, the soil becomes a clay loam, still open. It constitutes, in short, the entire vegetable matter of the soil. It has been applied to all the fields but two, which are yet undone. The horses were severely worked in carting on this substance to the land, on account of the deep rutting of the wheels which so much

Digitized by Google

cartage on deep plowed land occasioned. They, nevertheless, retained their good health, and still work on the farm. In dry weather the plowing-in of this matter was heavy, not so much on account of the deep furrow as the rutted state of the ground. This substance is found acceptable to all sorts of plants in the garden. It is a complete deodorizer of liquid manure. It was put on the land to keep it open, and lime will only be subsequently applied to meet the wants of vegetation. It is used as a bottoming to all the courts and boxes in the steading, with the view of absorbing the liquid from the cattle, and of making a compounded manure with straw.

This vegetable matter, after being plowed in, is beneficially acted on by the atmosphere; it incorporates with the soil, and saves a furrow in the working of the land. Beside this substance, the turnips in 1854 were manured with 2½ cwt. of guano. When the matter is laid on in dry weather, the turnips are always good; but in wet, the rutting of the soil has an injurious effect upon them. This substance proves of no inconvenience to the singling of the turnip plants, except when an occasional large lump may have been left unbroken. The turnips raised by it were the purple-top yellow and green globe. When the barley land is covered with this substance, it is plowed and sown without any dung. The barley crop of 1854, treated in this manner, weighed 16 stones 3 lb. the boll of 4 bushels, or nearly 57 lb. the bushel—a heavy weight for barley. When not treated with vegetable matter, the barley land only receives one furrow, and that furrow is given at any time the land is in a proper state for it, even as early as November, after the turnips have been stored. The subsequent rains do not render the land firm with this substance in it, and the land harrows freely. Barley is here found to have a darker color after turnips, raised with guano and carried off, than when eaten off by sheep.

The stubble of Cauldside field, of 22 acres, was plowed 15 inches deep, with three horses abreast, in the autumn of 1850. The land was bare-fallowed in 1851, and covered with the

Digitized by Google

vegetable substance in July and August, and received no other manuring. It was sown with Hunter's wheat early in September, with about 9½ cwt. of rape-cake per imperial acre. The rape-cake is found to have a better effect upon the future crop, when sown a day or two before the wheat, to allow it to be softened with dew or rain before being harrowed into the soil. The wheat plant grew apace, and was strong before winter, and its roots descended to the bottom of the pulverized subsoil before December. Roots of wheat at 9 inches below the surface, being unaffected by the winter frosts, are ready to shoot up with the first mild weather in spring. The crop of 1852 was 5½ quarters per imperial acre, and was of a quality to weigh 18 stones 13 lb. per boll of 4 bushels, or 66¼ lb. per bushel—a great weight for wheat grown above 700 feet above the level of the sea. A small portion of the young grass after wheat was reserved for cutting for the horses before being sent to pasture, and for hay. The hay crop was about 250 stones per imperial acre, of 22 lb. to the stone. The remainder of the grass was pastured with Cheviot ewes and their lambs, got by Leicester tups, keeping three ewes and their lambs to the acre. Four scores of ewes had seven scores of lambs, and three of the ewes had three lambs each. The lambs were sold for £1 each. The aftermath, after the lambs were gone, was pastured with cows and horses. In the second year the grass was pastured by Kyloe cows and their calves, as also by horses and cows. The stocking was equal to one head of oxen per acre.

The Easter Muir field, with originally a stiff hard clay soil, and clay moorband pan subsoil, containing 22¾ acres imperial, was in oats when in an undrained state, which produced 74½ quarters, equal to 31½ bushels the acre. It was thoroughdrained and bare-fallowed in 1849. In 1850 it carried oats, which produced 103½ quarters, equal to 43¼ bushels the acre. In 1851 it was bare-fallowed, manured with 180 cubic yards of the vegetable matter per acre, and deep-plowed with the Tweeddale plow to the depth of 14 inches. In 1852 it was in

Digitized by Google

wheat, which produced 91¼ quarters of good, and 6½ quarters of light wheat, equal to 41¾ bushels the acre, realizing £12, 18s. 9d. the acre. In 1853 the young grass kept seventy ewes and seventy-three lambs all the season, and twenty cattle from 12th to 26th July. In 1854 the second year's grass kept twenty cattle, from 27th April to 19th May, when it was afterward let for the season at £40.

The Greenlaw field, of originally a stiff sandy clay soil, and a clay subsoil, with much moorband pan and stones, containing 43¼ acres imperial, was in oats, after old grass undrained, which produced 139¼ quarters, equal to 30¾ bushels the acre. It was thorough-drained in 1852, manured with 180 cubic yards of the vegetable matter, and deep-plowed with the Tweeddale plow to the depth of 14 inches, and prepared for turnips and bare fallow. In 1853, 26½ acres were in wheat, which produced of good 60½ quarters, and of light 2½ quarters, equal to 22¾ bushels the acre, realizing £10, 1s. 4d. the acre; and 16¾ acres grew barley, which of good produced 61¾ quarters, and 5¼ quarters of light, equal to 38¼ bushels the acre, realizing £9, 2s. 6d. the acre.

The wheat realized, altogether, ...	£276	15	6
The barley realized, altogether, ...	159	16	7½
Together, ...	£436	12	1½

In 1854 the young grass kept eighty ewes and one hundred and thirty-one lambs from March. The lambs were sold in July and August, and the ewes in October and November—all fat. It also kept a mare and foal all the season; three cows from 1st August to end of October; seven farm-horses from 28th August to 1st November; and thirteen calves all October. It yielded. beside, 1000 stones of hay, at 9d. per stone. The second year's grass will be in 1855.

The particulars contained in the foregoing statements afford some useful information. Before the thorough-drainage of Danskine farm, the oats yielded about 30 bushels the acre. Thorough-draining alone increased the yield of oats to above

Digitized by Google

40 bushels, the increase of 10 bushels being more than 400 lb. of grain in weight from the acre: while deep-plowing and manuring with vegetable matter, superadded to the thorough-draining, caused the increase to exceed 40 bushels of wheat, being an increase in weight of grain of at least 630 lb. to the acre. An increase to the power of land to raise 40 bushels of wheat, instead of 30 bushels of oats, will be appreciated by every practical farmer. Even the inferior crop of 1853 on the same farm realized the sum of £436, 12s., off 43 acres—upward of £10 an acre; while the entire cost of draining, deep-plowing, and vegetable manuring, was a little above £13 an acre. As the vegetable matter would be available for the future crops of the rotation, and had 1853 been as good a year for wheat as the one before, or the year after, that single crop would have repaid the entire expenses, heavy as they necessarily were.

On the Moss Bents field of Yester Mains the subsoil-trench-plowing, and manuring with farm-yard dung on bare fallow, produced 38½ bushels of wheat per acre in 1852; while previously the same field, after being thorough-drained, yielded only 29 bushels of oats. The oats would weigh 1160 lbs., and the wheat 2400 lbs., which is more than double the weight of grain, and of a superior kind, too, from the area. The Long Bents field, on the same farm, yielded, in 1848, 37 bushels of oats the acre; and in 1853, after being subsoil-trench-plowed, it yielded 61 bushels of oats to the acre, making a difference of 1080 lbs. of grain to the acre in favor of the pulverization of the subsoil.

The Holmes Park of Broadwoodside farm, after being subsoil-trench-plowed in 1850, carried 43¼ bushels of oats to the acre in 1851, and 39 bushels of barley in 1853. The Kitchen Croft of the same farm yielded 34½ bushels of wheat in 1850, after being subsoil-trench-plowed and bare-fallowed, and in 1852, 53 bushels of barley to the acre.

Such crops of grain as these indicate the soil to be in a sound bearing state; and they are results very different from

Digitized by Google

what was to be expected from the same land at one time worth not more than from 6s. to 10s. an acre. But the increase is still more striking in the green crops of turnips and grass. The turnips have increased from a very moderate crop of certainly not more than 12 or 15 tons on the acre, though not weighed, to upward of 30 tons the acre, ascertained by weight and measurement. Such an increase as this, in a root so valuable as the turnip, is incalculable, as its quality in food increases proportionately with the weight of crop. The grass, as green forage and pasture, affords a remarkable instance of improvement. A yield of 250 stones of hay the acre is a heavy one from any soil, but remarkably so from a soil so recently almost in a state of nature. The maintenance of three ewes with their lambs, many of them double, on the acre, indicates a feeding power in the improved soil of no mean order; and the same result is confirmed on the pasture of Danskine, a high-lying farm, supporting, in a thriving condition all summer, an ox to the acre.

Every practical farmer will be able to appreciate the value of so much increased produce from the soil, of the various crops raised in this country, as have been enumerated. He knows that land, which was originally worth 10s. an acre overhead, yielding such crops as the above figures indicate—and the figures are derived from books most accurately and minutely kept—is now worth a great deal more. Not having been let to tenants since their improvement, it is difficult to put a market value upon the land as regards rent; but experience would not consider it stretching a point were it stated, as the belief of one, that the land had increased in value four or perhaps five fold. Indeed, when the great saving in working the farm for the future is taken into due consideration, the value of the land is even more than what has been suggested. One circumstance corroborates such a conclusion. Both the wheat and the barley grown on the Yester farms now realize the top prices in the Haddington market; and the Haddington market is a severe test on the value of any grain presented

Digitized by Google

at it, inasmuch as grain is shown there that has been raised on as good soil, as favorable a climate, and with as much skill as in any district of the kingdom. But wheat that has attained 66 lbs., barley 57 lbs., and oats 44 lbs. the bushel, need not fear competition in any market, and from any locality.

Besides these direct instances of the increase of produce, the economy of the system may be judged of by the following particulars:—

It is the opinion of the stewards upon the farms, that six pairs of horses will now be able to accomplish what it has taken eight pairs to do hitherto. Here, then, in one department of labor alone, is a saving of 25 per cent. This is the opinion of men who have been plowmen themselves, and who had seen the state of the soil before as well as after the improvements, and who have therefore been many years in the service of the Marquess.

Economy in horse labor arises from cessation of plowing, from the autumn cross-plowing of the stubble to the making up of the land for turnips in spring. The advantage of a cessation from plowing in winter will be best understood by those who have heavy clay soils to manage, even after being thorough-drained; because if such were stirred at any time in spring in a moist state, or before a fall of rain, they are sure to be converted in the first dry weather, into tough obdurate clods, which require no inconsiderable amount of labor to reduce, and to effect which, clod-crushers, grubbers, and rollers must be called into requisition. The Yester deep-plowed land requires no such assistance.

Such a direct saving of labor is a great furtherance to having the spring work so far advanced in autumn as to render the farmer independent of the weather both in winter and spring. The winter furrow lies snugly awaiting the call in spring, at the time when it is in the best state to be worked; and should the weather still prove adverse, the land can wait for the best weather, since it is already in a sufficiently pulverized state. The power of thus only working the soil

Digitized by Google

when it is in the best state to receive the labor is equivalent to a saving of labor.

A saving may also be effected in the purchase of implements. Many of the most costly implements employed on farms, such as Norwegian harrows, Crosskill's clod-crushers, grubbers, rollers, are used only for pulverizing the soil. The occupation of such implements is gone in the Yester deep land-culture. The subsoil-trench-plowing, by one double operation, effectually and permanently pulverizes not only the soil, but the subsoil to the depth of nineteen or twenty inches; and the Tweeddale plow itself afterward maintains the soil in a state of pulverization to the depth of fifteen inches, leaving still a stirred subsoil of four or five inches beneath a really unusually deep furrow. Experience has fully established that, from the pulverized state of the soil in spring, no other implements are wanting for the cultivation of the soil than the plows described above, together with the common harrow with longer tines.

Another saving is effected in the manual labor bestowed on the fields. The deep-plowing having eradicated all the strong-rooted weeds, no wrack or couch grass has to be hand-picked, few stones to be gathered from the surface, no large plants to be weed-hooked among the growing crops. Such a saving as this is not easily estimated, but the work it saves usually constitutes an item in farm expenditure worthy of consideration.

The hastening of the ripening of grain crops in an upland or late district is one of the advantages insured by the Yester system of deep land-culture. A harvest delayed for a fortnight or three weeks beyond the period it might have been ready, is a serious consideration for the farmer, both in the cutting down and in the gathering in of the crop. The entire value of a crop of wheat or of barley may depend upon the state of the weather experienced after such a delay; and in a late harvest the days are, besides, much shorter for executing so great a work as a harvest always is.

Digitized by Google

Besides the positive advantages derivable from this system of land cultivation, there are negative ones of equal value. Let any amount of rain fall upon the pulverized soil and subsoil, attained by means of subsoil-trench-plowing, to nineteen inches in depth, and the soil never becomes in a sour and poachy state; and observation has proved that it never again becomes so cold as land in the commonly cultivated state. This negative advantage produces a positive one, which is, that young wheat-plants and young clovers are never thrown out of the ground in winter or spring, however late or cold the weather may be. Another thing is, that snow lies a shorter time on the ground in spring. This arises from the frost not having a moist soil to act upon, and it therefore does not leave the surface-soil in a state of apparent fermentation, in which weak soils seem often to be in spring.

Clod Crusher.

After the field has been well plowed with a double plow (the Columbus and the Michigan double plow being the only ones of which the writer has any knowledge), should

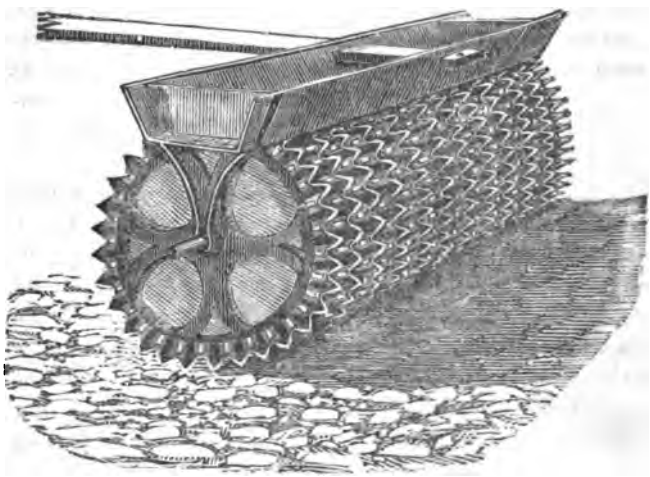


Fig. 24.

Digitized by Google

where appear to be lumpy or cloddy, a great benefit will undoubtedly be derived, if the soil is dry, from a common field roller; this will pulverize many of the clods or lumps which cohered too firmly to be comminuted with the plow. In England, an implement called "*Crosskill's Clod Crusher*" is extensively used; and one equally as good is now manufactured in Columbus, O. The cut on the preceding page and the following correspondence, copied from the *Ohio Cultivator*, will convince the intelligent reader of the necessity of such an implement, as well as convey an idea of the structure and working of the *Crusher* itself.

FRIEND HARRIS: I have been thinking of making a roller with spikes in it, but I am afraid to try it. I thought of cast spikes one inch in diameter, and six inches out of the log and four in it, but I am afraid they will break. The cost would be greater than I expected ($15. I think, for spikes); and if they break, it will be an experiment for the benefit of my neighbors, as well as myself, at my expense.

Will thee please give me some information, through the *Cultivator*, if there has been an implement made of that sort; also, if there are any for sale in this State. There is something of the kind much needed to pulverize the ground before putting in the seed, such a season as this in particular. The corn ground in this locality is, a large portion of it, very cloddy and hard, so that a common roller and harrow will not do the work as it should be.

Please give us some information about how to construct a spike roller or where to get one. My uncle made one, last fall, with wooden spikes, that will pulverize the hardest clods. It will not clog, unless the ground is too wet to harrow. The rows or spikes are diagonal, about five inches apart each way, and sharpened after they were put in. I would like to have something more durable, if it did not cost too much. Stir up the farmers, and tell them not to look complacently on their cloddy fields, and say they can't help it. PAUL TOMLINSON.

Highland Co., 6th mo., 1859.

ANSWER.—The spike roller will, no doubt, serve a good purpose, where nothing better can be had; but for a thing to do the business for certain, we nominate GILL'S CLOD CRUSHER, of which the above cut is an illustration. This machine consists of 14 rings or sections, made of cast iron, 30 inches in diameter, the spokes about an inch thick, and the face a corrugated blunt chisel edge, covering some five inches in

Digitized by Google

width. The whole length of the roller is 7 feet. The whole face is sin foliated, indented, and corrugated, that it will crush and divide any clod or lump not literally as firm as a stone. It is so constructed as to openness of face and independence of action, that it can not be clogged on any land that is dry enough to have a roller used upon it. Each ring plays separately upon the shaft, which is of wrought iron, two inches in diameter. At the ends of the shaft are gudgeons or axles, to put on carrying wheels, for taking the roller to the field with the same facility as an ox-cart is moved. The whole weight of the roller is about a ton. It will never wear out, or get out of order. Hon. Thos. Ewing, of Fairfield Co., who should be well known to every citizen of Ohio and the Union, after using one of Gill's Clod Crushers for a week, writes to say that it is the unanimous verdict of his hands, that "it is the bulliest thing among clods they ever saw!" in which opinion Mr. Ewing concurs.

This Clod Crusher does not pack the soil like a roller, but leaves it all light and fine. Ever since we saw the Scotch Clod Crusher of Crosskill, in the N. Y. Crystal Palace Exhibition in 1853, we have been in hope some of our manufacturers would take hold of this matter; and we are glad to learn that J. L. Gill & Son of this city are now fully enlisted in the enterprize, and that their machine is far superior to Crosskill's.

In order to exhibit more fully and clearly the necessity of pulverizing the soil, or making it as fine as possible, we have extracted the following from a lecture on Agricultural Science by Dr. Madden, of England; in which the subject is not only clearly and forcibly stated, but at the same time philosophically also.

"The first thing which occurs after the sowing of the seed is, of course, *germination;* and before we examine how this process may be influenced by the condition of the soil, we must necessarily obtain some correct idea of the process itself. The most careful examination has proved that the process of germination consists essentially of various chemical changes, which require for their development the presence of air, moisture, and a certain degree of warmth. Now, it is obviously unnecessary for our present purpose that we should have the least idea of the nature of these processes: all we require to do is, to ascertain the conditions under which they take place; having detected these, we know at once what is required to make

Digitized by Google

a seed grow. These, we have seen, are air, moisture, and a certain degree of warmth; and it consequently results, that wherever a seed is placed in these circumstances, germination will take place. Viewing matters in this light, it appears that soil does not act *chemically* in the process of germination; that its sole action is confined to its being the vehicle by means of which a supply of air and moisture and warmth can be continually kept up. With this simple statement in view, we are quite prepared to consider the various conditions of soil, for the purpose of determining how far these will influence the future prospects of the crop, and we shall accordingly at once proceed to examine carefully into the *mechanical relations of the soil.* This we propose doing by the aid of figures. Soil, examined mechanically, is found to consist entirely of particles of all shapes and sizes, from stones and pebbles, down to the finest powder; and, on account of their extreme irregularity of shape, they can not lie so close to one another as to prevent there being passages between them; owing to which circumstance soil in the mass is always more or less *porous.* If, however, we proceed to examine one of the smallest particles of which soil is made up, we shall find that even this is not always solid, but is much more frequently porous, like soil in the mass. A considerable portion of this finely-divided part of soil, *the impalpable matter*, as it is generally called, is found, by the aid of the microscope, to consist of *broken-down vegetable tissue*, so that when a small portion of the finest dust

Fig. 25.

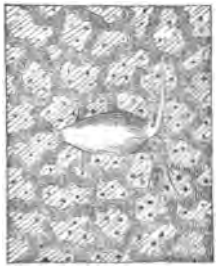


Fig. 26.

Digitized by Google

from a garden or field is placed under the microscope, we have exhibited to us particles of every variety of shape and structure, of which a certain part is evidently of vegetable origin.

In these figures I have given a very rude representation of these particles; and I must beg you particularly to remember that they are not meant to represent by any means accurately what the microscope exhibits, but are only designed to serve as a plan by which to illustrate the mechanical properties of the soil. On referring to Fig. 25, we perceive that there are two distinct classes of pores: first, the large ones, which exist *between* the particles of soil; and, second, the very minute ones, which occur in the particles themselves; and you will at the same time notice, that whereas all the larger pores—those between the particles of soil—communicate most freely with each other, so that they form canals, the small pores, however freely they may communicate with one another in the interior of the particle in which they occur, have no direct connection with the pores of the surrounding particles. Let us now, therefore, trace the effect of this arrangement. In Fig. 25, we perceive that these canals and pores are all empty, the soil being *perfectly dry;* and the canals communicating freely at the surface with the surrounding atmosphere, the whole will of course be filled with air. If, in this condition, a seed be planted in the soil, you at once perceive that it is freely supplied with air, *but there is no moisture;* therefore, when soil is *perfectly dry*, a seed can not grow.

Let us turn our attention now to Fig. 26. Here we perceive that both the pores and canals are no longer represented white, but black, this color being used to indicate water; in this instance, therefore, water has taken the place of air, or, in other words, the soil is *very wet.* If we observe our seed now, we find it abundantly supplied with water, but *no air.* Here again, therefore, germination can not take place. It may be well to state here, that this can never occur *exactly* in nature, because, water having the power of dissolving air to a certain extent, the seed in Fig. 26 is, in fact, supplied with

Digitized by Google

a *certain* amount of this necessary substance; and, owing to this, germination does take place, although by no means under such advantageous circumstances as it would were the soil in a better condition.

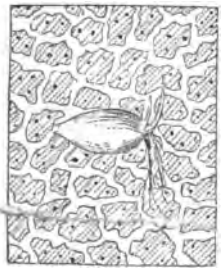
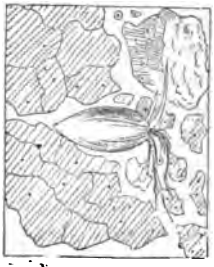


Fig. 27.



We pass on now to Fig. 27. Here we find a different state of matters. The canals are open and freely supplied with air, while the pores are filled with water; and consequently you perceive that, while the seed has quite enough of air from the canals, it can never be without moisture, as every particle of soil which touches it is well supplied with this necessary ingredient. This, then, is the proper condition of soil for germination, and in fact for every period of the plant's development; and this condition occurs when soil is *moist*, but not *wet*—that is to say, when it has the color and appearance of being well watered, but when it is still capable of being crumbled to pieces by the hands, without any of its particles adhering together in the familiar form of mud.

Turning our eyes to Fig. 28, we observe still another condition of soil. In this instance, as far as *water* is concerned, the soil is in its healthy condition—it is moist, but not wet, the pores alone being filled with water. But where are the canals? We see them in a few places, but in by far the greater part of the soil none are to be perceived; this is owing to the particles of soil having adhered together, and thus so far obliterated the interstitial canals, that they appear only

Digitized by Google

like pores. This is the state of matters in every *clod of earth;* and you will at once perceive, on comparing it with the upper right hand portion, which represents a stone, that these two differ only in possessing a few pores, which latter, while they may form a reservoir for moisture, can never act as vehicles for the *food* of plants, as the roots are not capable of extending their fibers into the interior of a clod, but are at all times confined to the interstitial canals.

With these four conditions before us, let us endeavor to apply them *practically* to ascertain when they occur in our fields, and how those which are injurious may be obviated.

The first of them, we perceive, is a state of too great dryness, *a very rare* condition, in this climate at least; in fact, the only case in which it is likely to occur is in very coarse sands, where the soil, being chiefly made up of pure sand and particles of flinty matter, contains comparatively much fewer pores; and, from the large size of the individual particles, assisted by their irregularity, the canals are wider, the circulation of air freer, and, consequently, the whole is much more easily dried. When this state of matters exists, the best treatment is to leave all the stones which occur on the surface of the field, as they cast shades, and thereby prevent or retard the evaporation of water.

We will not, however, make any further observations on this very rare case, but will rather proceed to Fig. 26, a much more frequent, and, in every respect, more important condition of soil: I refer to an *excess of water.*

When water is added to perfectly dry soil, it, of course, in the first instance, fills the interstitial canals, and from these enters the pores of each particle; and if the supply of water be not too great, the canals speedily become empty, so that the whole of the fluid is taken up by the pores: this, we have already seen, is the *healthy* condition of the soil. If, however, the supply of water be too great, as is the case when a spring gains admission into the soil, or when the sinking of the fluid through the canals to a sufficient depth below the surface is

Digitized by Google

prevented, it is clear that these also must get filled with water so soon as the pores have become saturated. This, then, is the condition of *undrained soil.*

Not only are the pores filled, but the interstitial canals are likewise full; and the consequence is, that the whole process of the germination and growth of vegetables is materially interfered with. We shall here, therefore, briefly state the injurious effects of an excess of water, for the purpose of impressing more strongly on your minds the necessity of thorough-draining, as the first and most essential step toward the improvement of your soil.

The *first* great effect of an excess of water is, that it produces a correspohding diminution of the amount of air beneath the surface, which air is of the greatest possible consequence in the nutrition of plants; in fact, if entirely excluded, germination could not take place, and the seed sown would, of course, either decay or lie dormant.

Secondly, an excess of water is most hurtful, by reducing considerably the *temperature* of the soil; this I find, by careful experiment, to be to the extent of six and a-half degrees Fahrenheit in summer, which amount is equivalent to an elevation above the level of the sea of 1,950 feet.

These are the two chief injuries of an excess of water in soil which affect the soil itself. There are very many others affecting the climate, etc.; but these not so connected with the subject in hand as to call for an explanation here.

Of course, all these injurious effects are at once overcome by thorough-draining, the result of which is, to establish a direct communication between the interstitial canals and the drains, by which means it follows that no water can remain any length of time in these canals without, by its gravitation, finding its way into the drains.

The 4th Fig. indicates badly-cultivated soil, or soil in which large unbroken clods exist; which clods, as we have already seen, are very little better than stones, on account of their impermeability to air and the roots of plants.

Digitized by Google

Too much can not be said in favor of pulverizing the soil; even thorough-draining itself will not supersede the necessity of performing this most necessary operation. The whole valuable effects of plowing, harrowing, grubbing, etc., may be reduced to this: and almost the whole superiority of *garden* over *field* produce is referable to the greater perfection to which this pulverizing of the soil can be carried.

The whole success of the drill-husbandry is owing, in a great measure, to its enabling you to stir up the soil well during the progress of your crop; which stirring up is of no value beyond its effects in more minutely pulverizing the soil, increasing, as far as possible, the size and number of the interstitial canals.

Lest any one should suppose that the contents of these interstitial canals must be so minute that their whole amount can be of but little consequence, I may here notice the fact, that, in moderately well pulverized soil, they amount to no less than one-fourth of the whole bulk of the soil itself; for example, 100 cubic inches of *moist* soil (that is, of soil in which the pores are filled with water while the canals are filled with air), contain no less than 25 cubic inches of air. According to this calculation, in a field pulverized to the depth of eight inches, a depth perfectly attainable on most soils by careful tillage, every imperial acre will retain beneath its surface no less than 12,545,280 cubic inches of air. And, to take one more element into the calculation, supposing the soil were not properly drained, the sufficient pulverizing of an additional inch in depth would increase the escape of water from the surface by upward of one hundred gallons a day."

Digitized by Google

CHAPTER XVII.

IMPROVEMENT OF SOILS.

MANURING.—Much has been said and written about manuring and manures. Common sense dictates that always abstracting and never replacing the equivalents taken from the soil, must in course of time impoverish it. But we are not prepared to admit that the soil in Ohio has been so thoroughly robbed of its fertile elements, during the half century of the State's transition from the red man's hunting-ground to the white man's garden, as to require dosing with patent manures to restore it to its virgin fertility. If Ohio's soil is already robbed of the principal portion of its productive elements, gloomy indeed is the picture which imagination thrusts on us of the future. England has been cultivated for a thousand years, and her farmers have not been in the habit of manuring systematically, more than fifty years—and to-day the soil there is richer than in Ohio.

What is required in Ohio, is a different system of culture—underdraining, deep culture, and generous manuring with farm-yard manure. With this system judiciously practiced the soil of this State can go on increasing in fertility for a hundred years to come.

In order to prove that farm-yard manure contains the necessary elements to be replaced in the soil, we have made a rather lengthy extract from a prize essay, written by Thos. Way, on Farm-yard Manure, from the pages of the Journal of the Royal Agricultural Society.

"DRAININGS OF DUNG-HEAPS.—Nobody can deny that farm-yard manure is seldom kept in the most efficient manner. In many places in England, especially in Devonshire, and in some

Digitized by Google

parts of Gloucestershire, it is a common practice to place manure-heaps by the roadside, often on sloping ground, and to keep these loosely erected heaps for a considerable length of time, before carting the dung on the field. On other farms, the manure is allowed to remain loosely scattered about in uncovered yards for months before it is removed. Heavy showers of rain falling on manure kept in such a manner, by washing out the soluble fertilizing constituents of dung, necessarily greatly deteriorate its value. It is well known that the more or less dark colored liquids which flow from badly-kept dung-heaps, in rainy weather, possess high fertilizing properties. According to the rain which falls at the time of collecting these drainings, according to the character of the manure, and similar modifying circumstances, the composition of the drainings from dung-heaps is necessarily subject to variations. The general character of these liquids, however, is the same in dilute and in concentrated drainings. Several samples of dung drainings were recently examined by me, and, from this analysis it will be seen that they contain a variety of fertilizing constituents, which it is most desirable to retain in dung-heaps.

The first liquid examined was collected from a dung-heap composed of well-rotted horse dung, manure from fattening beasts, and the dung from sheep pens. Both the horse dung and dung from fattening beasts were made in boxes. The liquid which ran from this dung-heap was collected in rainy weather, and contained, no doubt, in addition to the liquid portion of the dung, a good deal of rain.

The amount of free ammonia (ammonia expelled on boiling the liquid) in these drainings was determined in the manner described above; and after the free ammonia was removed, quick-lime was added to the remainder of the concentrated liquid, for the purpose of separating any ammonia present in the form of salts, which are not decomposed simply by boiling.

In this way the following results were obtained :—One imperial gallon of drainings contained 36.25 grains of free ammonia, and 3.11 grains of ammonia in the form of salts, not

Digitized by Google

decomposed simply in boiling, but by continued boiling with quick-lime. Evaporated to dryness, 7,000 grains furnished 62.51 grains of solid matter, dried at 212° Fahr.; or one imperial gallon was found to contain 625.10 grains of solid matters. On heating to redness, 62.51 grains left 36.89 grains of ash. This ash was submitted to a detailed analysis, and calculated for one imperial gallon of the drainings. According to the analytical results obtained in these different determinations, an imperial gallon of these drainings contained—volatile and combustible constituents, 395.66.

Ammonia driven out in boiling, ... 86.25		
Ammonia, in the state of salts, decomposed by quick-lime, ... 3.11	Together 89.36	
Ulmic and humic acid, ...	125.50	
Carbonic acid, expelled on boiling, ...	88.20	
Other organic matters (containing 3.59 of nitrogen),	142.60	
		395.66

Cineral matters (ash), 368.98, viz.:

Soluble silica, ...	1.50	
Phosphate of lime, with a little phosphate of iron, ...	15.81	
Carbonate of lime, ...	84.91	
Carbonate of magnesia, ...	25.66	
Sulphate of lime, ...	4.86	
Chloride of sodium, ...	45.70	
Chloride of potassium, ...	70.50	
Carbonate of potash, ...	170.54	
		368.98
Total, per gallon, - - -		764.64

These analytical results suggest the following remarks:—

1. It will be seen that these drainings contain a good deal of ammonia, which should not be allowed to run to waste.

2. They also contain phosphate of lime, a constituent not present in the urine of animals. The fermentation of the dung-heap thus brings a portion of the phosphates contained in manure into a soluble state, and enables them to be washed out by any watery liquid that comes in contact with them.

Digitized by Google

3. Drainings of dung-heaps are rich in alkaline salts, especially in the more valuable salts of potash.

4. By allowing the washings of dung-heaps to run to waste, not only ammonia is lost, but also much soluble organic matter, salts of potash and other inorganic substances, which enter into the composition of our crops, and which are necessary to their growth.

II. *Drainings from another Dung-heap.*

These drainings were not so dark colored as the preceding ones. Like the former liquid, it was neutral, but gave off ammonia on boiling, and on addition of quick-lime.

Hydrochloric acid produced a dark-brown colored, flaky deposit, leaving the liquid only pale yellow.

The amount of the precipitated humus acid was much smaller than in the preceding liquid.

For want of a sufficient quantity of liquid, only the amount of solid matter contained in it could be determined.

An imperial gallon on evaporation furnished 353.36 grains of solid matter, dried at 212° Fah.

III. *Drainings from a third Dung-heap.*

A dung-heap, composed chiefly of mixed fresh horse, cow's, or pig's dung, furnished the material for the third analysis of drainings. This liquid was much darker than the two preceding liquids, possessed an offensive smell, although it contained no sulphureted hydrogen. It was neutral to test-paper, consequently did not contain any free or carbonate of ammonia. On heating, ammonia escaped; apparently, however, in much smaller quantities than from the preceding drainings. This liquid was collected at a time when no rain had fallen for several weeks, which circumstance accounts for its greater concentration. It was submitted to the same course of analysis as the first drainings. 7,000 grs. evaporated to dryness produced 135.774 grs. of dry matter; and this quantity, on

Digitized by Google

burning in a platinum dish, furnished 62.58 grs. of mineral matters. A separate portion was used for the determination of the amount of the ammonia present in the form of salts; and another portion of liquid, acidulated with a little hydrochloric acid, evaporated to dryness, was employed for the determination of the whole amount of nitrogen. By deducting the amount of nitrogen found in the ammoniacal salts, from the total amount of nitrogen obtained by combustion of the solid matter with soda-lime, the proportion of nitrogen contained in the organic substances of these drainings, was ascertained. The following table represents the composition of the solid substances found in one imperial gallon of drainings from fresh manures:

Composition of solid matter in one gallon of drainings from fresh farm-yard manure.

Ready formed Ammonia (principally present) as humate and ulmate of Ammonia	15.18	
Organic Matter	716.81	
Inorganic matters (ash)	625.80	
Total amount of solid matter in one gallon of drainings		1357.74
Containing Nitrogen		31.08
Equal to Ammonia		37.78
625.80 of ash consisted of:		
Silica		9.87
Phosphates of lime and iron		72.65
Carbonate of lime		59.58
Sulphate of lime		14.27
Carbonate of magnesia		9.95
" " potash		297.88
Chloride of potassium		60.64
" " sodium		101.82

It will be observed that these drainings contain about double the amount of solid matter which was found in the liquid from the first heap. The composition of this solid matter compared with that of the solid matter in the liquid

Digitized by Google

from the first heap, moreover, presents us with some particulars to which it may be advisable briefly to allude.

In the first place I would remark, that notwithstanding the greater concentration of the third liquid, as compared with the first, the proportion of ammonia present in the form of ammoniacal salts was less, while the drainings from fresh dung contained the larger portion of this element in the form of soluble organic substances. The most important constituent of farm-yard manure, *i. e.*, nitrogen, is thus liable to be wasted in the drainings, whether they proceed from rotten or fresh manure, for in either case it passes off in a soluble state of combination. While speaking of the nitrogen in the drainings of dung-heaps, I ought to mention that in both the liquids examined in detail, I have detected readily the presence of nitric acid. In the liquid from fresh manure there were apparently mere traces of nitrates, but in that from rotten dung the proportion of nitric acid was so considerable that I hoped to be able to determine it quantitatively. But I found the large amount of soluble organic matter to interfere sadly with the nitric acid determination; and, unable to supply for the present correct results, I merely mention the fact that these liquids contained nitrates, and trust to be able to supply this deficiency in these analyses at a future period. In the next place I would observe, that the proportion of organic and inorganic matters, bear to each other different relations in the first and in the third liquid.

In the liquid from rotten dung the proportion of mineral matter exceeds that of organic substances, and in the third liquid the reverse is the case. We learn from this that soluble organic matters are very liable to become decomposed; and it is not unlikely that all putrescent organic matters before assuming a gaseous state, are first changed into soluble matters.

In the first stage of decomposition, *i. e.*, during the active fermentation of dung, the constituents of farm-yard manure

Digitized by Google

are rendered more and more soluble; hence up to a certain point the amount of soluble organic matters increases in manures. But when active fermentation in manure heaps becomes gradually less and less energetic, and finally ceases, the remaining fermented manure is still liable to great and important changes, for it is subject to that slow but steady oxidation or slow combustion, which has been termed appropriately, by Liebig, Eremacausis. To this process of slow oxidation all organic substances are more or less subject. It is a gradual combustion which terminates with their final destruction.

Hence the larger portion of organic matter in the liquid from the manure heap formed of fresh dung in an active state of fermentation, and the smaller portion of organic matter in the drainings of the first heap, in which the dung had passed the first stage of decomposition, and been exposed for a considerable period to the subsequent process of eremacausis or slow combustion. The formation of nitric acid from putrefying organic matter has long been observed, but the exact conditions under which it proceeds are by no means satisfactorily established, and much room is left to further extend investigations.

The mineral substances in the drainings from fresh dung are the same as those from rotten. Like the ash of the latter, the liquid from fresh dung-heaps contains soluble phosphates, soluble silica, and is rich in alkaline salts, especially in carbonate of potash, of which there are nearly 300 grs. in a gallon of the liquid. Sufficient evidence is thus presented in the analysis of these liquids, that as the drainings of both fresh and rotten dung heaps are allowed to flow into the next ditch, concentrated solutions of the most valuable constituents of dung are carelessly wasted.

With a view of preventing such a serious loss, I have suggested the propriety of carting the manure on the fields, whenever practicable, in a fresh state, and of spreading it at once.

Digitized by Google

It may be objected that the application of manure in a fresh state, equivalent to winter manuring, and especially the spreading of dung, will lead to waste, inasmuch as the rain which falls during the winter and spring, has much more chance of washing out fertilizing substances from dung than by applying it at the time of sowing. This objection would indeed be a valid one, if we were not acquainted with the fact that all soils containing a moderate proportion of clay possess the property of retaining the more valuable constituents of manure; but, this being the case, the objection on these grounds can not be admitted. With more force, however, it may be made with reference to light sandy soils, and it is indeed upon such soils that manure is best applied in spring.

In order to ascertain to what extent various soils possessed the powers of absorbing manuring constituents from the drainings of dung-heaps, I determined to employ a limited quantity of soil and a large excess of liquid. To this end two parts by weight of liquid were well mixed with one part by weight of soil, and left in contact with the latter for twenty-four hours, after which the clear liquid was drawn off and passed through a filter.

Experiments to Ascertain the Extent of Absorbing Properties of Soils of known Composition.

Experiment made with the drainings of dung-heaps composed of rotten dung. The drainings employed in this experiment were the same which contained in the imperial gallon 664 64 grains of solid matter, the detailed composition of which is given above. The composition of the soil used in the experiment is given below.

The surface-soil contained a good deal of organic matter, a fair proportion of clay, little sand, and a moderate proportion of carbonate of lime in the form of small fragments of limestone. It was a stiffish soil, belonging to the clay-marls. Its subsoil was richer in clay and of a more compact texture and

Digitized by Google

less friable character than the surface-soil. The mechanical analyses of soil and subsoil gave the following result:

	Surface-soil.	Subsoil.
Moisture when analyzed	5.86	3.66
Organic matter and water of combination	25.86	8.79
Lime	14.30	26.03
Clay	34.84	56.76
Sand	19.64	4.76
	100.00	100.00

In the chemical analysis of this soil the following results were obtained:

	Surface-soil.	Subsoil.
Moisture when analyzed	5.86	3.66
Organic matter and water of combination	25.86	8.79
Oxides of iron and alumina	13.88	10.13
Carbonate of lime	14.30	26.03
Sulphate of lime	.56	Not Determined.
Phosphoric acid and chlorine	traces	
Carbonate of magnesia	1.04	
Potash	07	1.67
Soda	18	
Insoluble silicious matter	38.75	49.73
	100.00	100.00

2,000 grains of this soil and 2,000 grains of subsoil were mixed with 4,000 grains of the liquid from rotten dung. After twenty-four hours the clear liquid was carefully drawn off and filtered. Its original dark-brown color was changed into a pale yellow color. This soil thus possessed in a high degree the property of decolorizing dark-colored liquids like the washings of dung-heaps.

1,200 grains of the filtered liquid, passed through soil, were distilled in a retort nearly to dryness, and the ammonia which was given off carefully collected in an apparatus containing hydrochloric acid, and so constructed as to secure the perfect absorption of ammonia.

Digitized by Google

The amount of chlorine of ammonia obtained on evaporation of the acid liquid in the receiving-vessel was .62 grains. This gives for one imperial gallon of liquid passed through soil 11.49 grains of ammonia.

Originally the drainings contained, per gallon	39.86
After filtration through soil they contained, per gallon	11.49
Absorbed by 70,000 grains of soil	27.87 am.

1,000 grains of this soil thus absorbed .396 of ammonia.

On evaporation of another portion of the same liquid passed through soil, one imperial gallon of filtered drainings was found to contain 164.88 of organic matter; 210.20 of inorganic matter.

Before filtration through soil, the imperial gallon contained 268.10 grains of solid organic substances; 368.98 of mineral matters.

A considerable quantity of both organic and mineral matters thus removed from the liquid in contact with the soil.

A similar experiment was made by diluting 4,000 grains of the same drainings with 4,000 grains of distilled water, and leaving the more dilute liquid in contact for twenty-four hours with 2,000 grains of the same soil, and 2,000 of subsoil.

The filtered liquid contained in the gallon:

Ammonia	6.91
Organic matters	118.50
Mineral matters	147.36
Total amount of solid matters in a gallon	272.77

The 147.36 of mineral matters (ash) consisted of:

Silica	2.88
Phosphates of lime and iron	1.54
Carbonate of lime	79.72
Carbonate of magnesia	6.17
Sulphate of lime	7.92
Chloride of Sodium	18.90
Chloride of potassium	26.44
Carbonate of potash	4.29

Digitized by Google

Originally the liquid employed in this experiment contained 19.68 grains of ammonia to the gallon. After passing through half its weight of soil, it contained only 6.91 grains of ammonia; consequently 12.77 were retained by 35,000 grains of soil, and 1,000 grains of the same soil absorbed .396 grains of ammonia. In both instances it was thus found that rather more than two-thirds of the amount of ammonia present in these drainings, in the form of ammoniacal salts, were retained by a very limited quantity of soil. I have purposely used a large amount of liquid in comparison with that of soil. If under such conditions, the soil is capable of retaining two-thirds of the whole amount of ammonia present in a liquid like the one examined, it is not too much to expect that no ammonia whatever will be lost in practice by carting manure on the fields in autumn, and spreading it at once. The quantity of soluble ammoniacal matters in a heavy dressing of the best dung does not amount to many pounds, and such a quantity, in relation to the weight of the soil ready to take up ammonia from the manure, is so insignificant that the most scrupulous may rest satisfied that in a soil containing even a small proportion of clay no ammonia will be lost by dressing the fields in autumn.

Other no less important changes than those referring to the absorption of ammonia will strike the reader to have taken place in these drainings left in contact with the soil. For better comparison sake, I will give the composition of the drainings before and after passing through soil, and then make a few additional remarks which are suggested by such a comparison.

Composition of Drainings from Rotten Dung.

One imperial gallon contains:

	Before filtration through soil.	After filtration.
Ammonia (in the form of ammoniacal salts)..	19.68	6.91
Organic matter.....	134.05	118.50

Digitized by Google

Silica	.75	2.88
Phosphate of lime and iron	7.90	1.54
Carbonate of lime	17.46	79.72
Sulphate of lime	2.18	7.92
Carbonate of magnesia	12.88	6.17
Chloride of sodium	22.85	18.90
Chloride of potassium	35.25	26.44
Carbonate of potash	85.27	4.29
	338.22	272.77

It will be observed that this liquid, in passing through the soil, has undergone a striking change. Leaving unnoticed several minor alterations in the composition of the original liquid, I would direct special attention to the very small proportion of carbonate of potash left in the draining after contact with this soil. It will be seen that, out of eighty-five grains of potash contained in the original liquid, no less than eighty-one grains have been retained by the soil. This is a result of the greatest importance, inasmuch as it shows that the soil possesses, in a remarkable degree, the power of removing from highly mixed manuring substances, not only ammonia from ammoniacal salts, but also the no less important soluble potash compounds. According to this result, 1,000 grains of soil absorb no less than 2.313 grains of carbonate of potash.

But, in addition to carbonate of potash, a considerable quantity of chloride of potassium is retained in this soil by passing the washings from rotten dung through it; for it will be observed that nearly nine grains of this salt, or in exact numbers, 8.81, were retained in the soil.

The avidity of the soil for soluble salts of potash is the more remarkable, as it offers a striking contrast to the apparent indifference of this soil to absorb soda from its soluble combinations; for it will be seen that the liquid, after filtration through the soil, contains only about four grains less of common salt in the gallon than before filtration.

In a purely chemical point of view, soda salts are closely

Digitized by Google

allied to salts of potash, and yet there is a marked difference observable in the power of this soil, at least, to absorb the one or the other alkali.

As regards the practical effect which salts of soda and potash are capable of displaying with reference to the nutrition of plants, the former are not to be compared to the latter in point of efficacy. It was believed at one time that soda was capable of replacing potash in the ashes of our crops, but this opinion was not based on trustworthy evidence. On the contrary, the best and most extensive series of ash analyses of our crops show that while the amount of potash, within certain limits, is constant in the ashes of plants, that of soda, especially of chloride of sodium, is liable to great fluctuations, arising, no doubt, from local conditions of the soil.

The fact that soils are capable of absorbing potash from soluble manuring matters, while no special care is manifested by them to retain the equally soluble soda salts, appears to me to account, to some extent at least, for the comparative constancy of the amount of potash in the ashes of our crops, as well as for the fluctuations of the amount of soda in the same. The power of soils to retain potash in large proportions must have the effect of converting the salts of potash in the manure applied to the land into compounds which, though not altogether insoluble in water, are yet sufficiently difficult of solution to permit only a limited and fixed quantity to enter into the vegetable organism in a given period. The case is different with salts of soda; for as soils do not appear to retain them in any high degree, and plants have no selecting power, but absorb by endosmosis whatever is presented to the spongioles of their roots in a state of perfect solution, it is evident that more soda will enter into the plants when grown on a soil naturally abounding in this alkali or heavily dressed with common salt, than when grown upon a soil poorer in soda.

We have here at the same time an interesting illustration of the fact, that the soil is the great work-shop in which food is

Digitized by Google

prepared for plants, and that we can only then hope to attain unto a more perfect knowledge of the nutrition of plants, and the best means of administering to their special wants, when we shall have studied, in all their details, the remarkable changes which we know, through the investigations of Mr. Thompson and Professor Way, take place in soils when manuring substances are brought into contact with them. The subject is full of practical interest, but also surrounded by great difficulties, which, it appears to me, can only be overcome when the investigation is taken up in a truly scientific spirit, without reference to the direct application which, in due course, no doubt, well established chemical principles will receive in agriculture. It is the undue anxiety to obtain at once what is popularly called a practical result—the grasping after results which may at once be translated into so many bushels of corn—which is a great hindrance to the more rapid advancement of agricultural science; and it is to be hoped, for the sake of the true interests of the really practical man, that the voice of those capable of understanding and appreciating purely scientific results, will be sufficiently powerful to keep in check the too great anxiety for immediate results.

In the next place, I beg to direct attention to the absorption by the soil of the phosphates contained in drainings. If it is borne in mind that the soil and subsoil with which the liquid was brought into contact, contained a large excess of carbonate of lime, it is not more than would naturally be expected, if we should see the soluble phosphates of the original drainings converted by the carbonate of lime into insoluble compounds.

Having already remarked upon the power of this soil to retain ammonia, I beg in conclusion to point out the large quantity of carbonate of lime in the filtered liquid as worthy of notice. This large amount of carbonate of lime is easily explained by the presence of much lime in the soil. Before filtration the liquid contained only about 17½ grains of carbonate of lime, and after filtration as much as nearly 80

Digitized by Google

grains. Thus while potash and ammonia are absorbed by the soil, lime is dissolved and passes into the liquid, which is filtered through the soil. Not only is the quantity of carbonate of lime considerably increased in the filtered drainings, but that of sulphate of lime in a minor degree also.

It is highly satisfactory to me to find the observations of Professor Way, with respect to the relative power of soils to retain ammonia, potash, soda and lime, confirmed in my experiments with a liquid containing a number of fertilizing agents required by our crops.

Before describing the next filtration experiments, I may state that I have thought it a matter of some interest to examine what amount of solid organic and inorganic matter to a given quantity of pure water would dissolve from the soil, the composition of which has been stated above. Accordingly, one part by weight of subsoil, and one part of surface soil, were mixed with four parts by weight of distilled water, and the whole, being occasionally stirred up, left to subside for twenty-four hours, after which time the water was filtered from the soil, and carefully analyzed.

An imperial gallon of this water was found to contain 84.88 grains of dry residue (dried at 220° Fah.), consisting of—

Organic matter, and a little water of combination,...	48.00
Carbonate of lime,...	26.84
Sulphate of lime,...	5.73
Phosphate of lime, with a little oxide of iron,...	.65
Carbonate of magnesia,...	.50
Chloride of sodium,...	1.25
Potash,...	.99
Silica,...	.92
	84.88

The amount of organic matter in this water is very great; it arises from the great excess of decomposing organic remains in the soil, and imparted to the water a yellow color and disagreeable smell, not unlike the smell of water in which flax is steeped. It will be further observed, that even pure rain-

Digitized by Google

water is capable of rendering soluble a considerable quantity of all those mineral constituents which are found in the ashes of our crops, and therefore are necessary to their growth.

2. *Filtration experiment made with the drainings of a dung-heap composed of fresh mixed Farm-yard Manure.*—Having ascertained in the previous filtration experiments, that a soil containing a good deal of clay and lime is capable of removing from compound manuring substances all the more valuable fertilizing constituents, I was anxious to determine to what extent soils deficient in both clay and lime, possessed the property of retaining fertilizing substances from drainings of dung-heaps. The composition of the liquid used for this experiment is given above; it is the same liquid collected from a fresh dung-heap, which in a gallon contained 1,357.74 grains of solid matter. The soil selected for experiment was a light, sandy, red-colored, very porous soil, containing, as will be seen by the following analysis, only little clay, and still less lime, but a good deal of organic matter. It was submitted to a minute and careful mechanical and chemical analysis, and furnished the results embodied in the subjoined tables:—

I. *Mechanical Analysis.*

Moisture,	3.45
Organic matter, and water of combination,	13.94
Coarse, white, quartz sand,	47.00
Fine, red sand, and a little clay deposited from water on standing five minutes,	19.82
Coarse clay, deposited on standing ten minutes,	2.82
Fine clay, deposited from water on standing one hour,	6.30
Finest clay, kept in suspension in water, after standing longer than one hour,	6.67
	100.00

It appears from these results, that nearly half the weight of this soil consists of pure white, coarse, quartz-sand, which can be readily separated by washing. The deposit which settled from water, after five minutes standing, consists chiefly

Digitized by Google

of fine, red sand, mixed with very little clay. The remainder is clay in a very finely subdivided state, besides humus, and some water of combination. The result of the mechanical examination thus shows that the proximate constituents of this soil are present in an advanced state of decomposition. In the following tabular statement the minute chemical composition of the same soil is given :—

II. *Chemical Analysis.*

Moisture,	8.45	
*Organic matter, and water of combination,	13.94	
Carbonate of lime,	.31	Containing together .39 of lime.
Sulphate of lime,	.53	
(Containing S. O.$_3$ 37)		
Alumina,	14.74	
Oxide of iron,	5.87	
Magnesia,	.18	
Potash (in a state of silicate),	.25	
Chloride of sodium,	.11	
Phosphoric acid, combined with iron and alumina (equal to bone-earth, 131),	.061	
Soluble silica (soluble in dilute potash),	7.42	
Insoluble siliceous matters (almost entirely white sand),	53.82	
	100.181	
*Containing nitrogen,	.192	
Equal to ammonia,	.228	

5,000 grains of this soil were mixed with 5,000 grains of liquid from a fresh manure heap, and 5,000 grains of distilled water. After twenty-four hours the clear liquid was filtered from the soil, and found to be somewhat lighter colored than before; but, in comparison with the decolorizing properties of the clay soils, used in the experiment, with the drainings from rotten dung, its effect upon the dark-colored organic compounds in the liquid appeared to be weak.

A portion of the filtered liquid was used for the determination of the ammonia contained in it, in the form of volatile

Digitized by Google

salts, or, at any rate, in the form of salts which yield ammonia on boiling their watery solution.

Another portion was evaporated to dryness, and the amount of nitrogen in the dry residue determined. The rest of the liquid was used for the determination of solid matter and ash.

Leaving unnoticed the details of these various determinations, I shall state at once the composition of the drainings passed through this light sandy soil. I may observe, however, that the ammonia and nitrogen, as well as the total amount of solid matter and ash in it, were determined twice, and closely agreeing results were obtained. An imperial gallon of liquid from fresh manure passed through red sandy soil contained:

Ready formed ammonia (chiefly as ulmate and humate of ammonia),	7.13
* Organic matter,	301.70
** Inorganic matter (ash),	245.70
Total amount of solid matter per gallon of liquid,	554.53
Containing nitrogen,	12.60
Equal to ammonia,	15.30

The ash (245 grains) consisted of:

Silica,	15.08
Phosphate of lime and iron,	38.14
Carbonate of lime,	21.22
Sulphate of lime,	trace.
Carbonate of magnesia,	2.36
Carbonate of potash,	85.93
Chloride of potassium,	39.49
Chloride of sodium,	48.48

It appears distinctly from these result that this soil possessed the power of absorbing manuring matters in a much smaller degree than the stiffer soil used in the preceding experiment. This agrees well with previous observations, in which it was found that soils in which sand greatly preponderates, exhibit

Digitized by Google

these useful absorbing properties in the least, and others in which clay preponderates, in the highest degree.

The soil used in the last experiment, it is true, contains a fair proportion of alumina; but this alumina exists principally in a free state, or at all events it is so loosely united with silica that it can be easily separated from this combination by dilute acids. The absorbing properties of soil, it thus appears, do not depend so much on the alumina contained in soils in a free state, but as shown already by Professor Way, rather in peculiar combinations, into the composition of which alumina enters. It is more than probable likewise that the different agricultural clays contain double silicates, to which Professor Way refers the absorbing properties of soils, in very variable proportions, and that consequently the agricultural capabilities of soils, so far as they are dependent upon these important properties, can not merely be ascertained by determining the proportion of clay which they contain. In short, the mere analysis of soils is not calculated to give us a fair idea of their true characters; nor does it appear to me to afford sufficient indications of what is really wanting in a soil in order to make it yield up heavy crops.

The nature of the changes which these drainings from fresh farm-yard manure underwent in contact with the soil, the analysis of which has just been given, will appear by glancing at the subjoined diagram, in which the composition of these drainings is stated before and after filtration through soil. An imperial gallon of liquid contained:

	BEFORE FILTRATION	AFTER FILTRATION *Through Soil.*
Ready formed ammonia,.....	7.67	7.13
Organic matters,.....	858.40	801.70
Inorganic matter (ash),.....	812.90	245.70
Total am't of solid matter per gallon,	678.97	554.53
Containing nitrogen,.....	15.54	12.60
Equal to ammonia,.....	18.86	15.30

Digitized by Google

	BEFORE FILTRATION	AFTER FILTRATION Through Soil.
Silica,	4.75	15.08
Phosphate of lime and iron,	86.82	83.14
Carbonate of lime,	29.79	21.22
Sulphate of lime,	7.14	trace.
Carbonate of magnesia,	4.98	2.36
Carbonate of potash,	148.69	85.93
Chloride of potassium,	30.82	39.49
Chloride of sodium,	50.91	48.48
** Total of ash,	312.90	245.70

The amount of ready-formed ammonia retained by this soil, it will be seen, is very trifling indeed; nor is the proportion of nitrogen, which is retained in the soil in the form of nitrogenized organic matters, very great. We are thus presented here with an instance, showing clearly that there are soils which do not possess the power of absorbing ammonia in any marked degree. In the case of such soils as the one used in this experiment, I think it would be hazardous to apply manure in autumn. I may also mention a curious circumstance in connection with this soil. I am informed that guano and ammoniacal manures do not seem to do much good on this soil, while the application of niter is followed with marked effect.

The most decided change in the composition of this liquid is observable in the proportion of potash which is contained in the filtered liquid; for as in the case of the former soil, a considerable quantity of this alkali has been absorbed by the sandy soil. On the other hand, there is only a trifling amount less chloride of sodium in the liquid after than before filtration, thus affording another proof that the power of soils to absorb potash is much greater than to retain soda. It will likewise be observed that, instead of yielding carbonate of lime to the liquid which was brought into contact with the light soil, some carbonate of lime and all the sulphate of lime were actually retained. This soil, it will be remembered, is deficient in lime. Perhaps it may not even contain suffi-

Digitized by Google

cient to supply the wants of some crops, and seems to be endowed with the property of absorbing lime from manuring matters, affording thereby an interesting instance how special provision is made in soils for the absorption of those constituents which are naturally deficient in them, and which are required in considerable quantities for the healthy and luxuriant growth of our crops.

In the preceding experiment just the opposite took place; for it will be remembered that the drainings, after passing through the calcareous clay soil, contained a great deal more of lime than before filtration. Similar differences will be observed with respect to other constituents originally present in the liquid and retained in the stiff and in the sandy soil in very different proportions. I abstain from noticing any minor changes in the composition of the filtered liquid, nor shall I indulge in any speculations respecting the compounds in the soil which have contributed to these changes, and the new combinations in the soil which may have resulted from them. Our present knowledge on the subject is far too imperfect to warrant us to theorize profitably on these matters; I therefore prefer to send forth for the present my analytical results without any further comment, and conclude by expressing the hope that I may be permitted to continue similar inquiries into the physiology of soils, and do not doubt that great and important practical benefits will, in due course, be derived from increased knowledge of the properties of soils and the changes manuring matters undergo when in contact with them.*

Manuring the Wheat Crop.

In the palmy days of wheat-growing in Western and Central New York, says the *Country Gentleman*, the application of active manures directly to this crop was not generally practiced. The opinion widely prevailed that such a course was injurious, by stimulating a heavy growth of straw at the ex-

* The above article on the absorbing qualities of soils, was written by Prof. Voelcker, and wrongly credited to Prof. Way.

Digitized by Google

pense of the grain, and in the rankness and succulency of the former, increasing the liability to lodge, and tending also to produce rust and mildew in the standing grain. In some instances, no doubt, high manuring has been followed by such results, but in many more, large crops of wheat have rewarded the application. We took occasion some eight years ago, to urge the subject upon the attention of our brother farmers, and the current of events influencing the wheat crop during that time, has brought it far more forcibly upon their attention.

We throw away our seed and labor, now-a-days, in sowing any but *rich*, warm, quick soils to wheat. We must get a large growth of healthy, early maturing plants, or the wheat midge will destroy the whole product. This we have urged in a former article, and will revert more strictly to the subject indicated in our heading.

Of all grains, says chemical analysis, wheat has in it more nitrogenous substances than any other. Fifteen per cent. of the organic matter of the grain of wheat belongs to this class. Although the straw may grow luxuriantly, the *grain* can not be formed without it. "Up to the formation of the kernels," says a writer on this subject, "ordinary soils, with rain, dew, and air, can furnish and grow the wheat plant. But when it comes to the fruiting part, the plant has to seek in the soil for materials out of which to fabricate its seed. It is necessary, therefore, that there be in such soil what we farmers call nutritive or putrescent manure—something out of which *nitrogen* can be formed." This is furnished in barn-yard manure, and other fertilizers of like character. These in a partially decomposed state (and hence furnishing almost immediately nutriment for the crop), we would apply to favorable soils before sowing them with wheat.

Many farmers have been in the habit of applying their stock of yard manure in a green or long state in the spring, to land intended for corn; reserving little or none for composting, or for application to the wheat crop. But this practice is becoming less general, and we now find frequently

Digitized by Google

those who prefer keeping the manure in the yard until well decomposed, and placing it in heaps for use the next season; applying it also upon winter grain, if they sow it, and as a top-dressing for grass land. This course is usually very successful. Though land heavily manured for corn, will produce good crops of wheat and barley following, it is seldom that the area which may be so manured and devoted, embraces half the extent we desire for growing grain, which would produce it if enriched sufficiently. Hence we see that we need more manure, as well as to study the most effective application of the same.

More manure may be had by composting that obtained from our farm stock with vegetable mold—the muck of swamps and marshes—the turf and wash of roads—the scrapings of ponds and ditches. We have doubled the amount and value of our yard manure by mixing it with muck from the swamp, and fermenting the same together in heaps loosely laid up and properly moistened. This was used at the rate of twelve loads per acre on land sown in wheat last autumn, being merely gang-plowed in before sowing. A small plot not dressed, shows a very marked difference—the growth is less than half of that on the manured portion, and the product will be of little if of any value.

We hope the lesson of the past few years will not be lost on those who begin, after all, to think the wheat midge less the enemy of the farmer than his own improvident course in cropping with this grain. If it shall induce us to a better enriching and cultivation of the soil, and a more careful study of the nature and demands of our different crops, it will prove to the country at large a blessing and not a curse. If it leads the mass of farmers, as it has many of them, to employ every available means of increasing the quantity and quality of the manure made upon their farms, and to study attentively the most effective application of the same for growing the most profitable crops, it will do more for the advancement of agriculture than almost any other means which are

Digitized by Google

likely to be employed. We would therefore urge immediate attention to the preparation of manure for applying to the wheat crop, and from our own experience and observation, think that composted manure, mixed with the surface soil by harrowing or very shallow plowing, will prove of the greatest benefit to the crop. This method is practiced by the most successful wheat-growers of the present day.

DRAINAGE.

There are comparatively very few soils which do not require drainage. The benefits and advantages resulting from drainage even on the best soils are so numerous and extended in their details, that it would require a volume rather than a few pages to discuss this subject properly. We shall content ourselves for the present on this subject, by making a few extracts from writers of acknowledged ability and practical observation, reserving what we may have to say in detail for a separate work.

It is a curious and apparently a paradoxical observation, says Johnston, that *draining* often improves a soil on which the crops are liable to be *burned up* in seasons of drought. Yet, upon a little consideration, the fact becomes very intelligible. Suppose that the surface-soil extend to a certain line, while below this there is a subsoil in which the water stagnates. The roots will readily penetrate to the line between these two soils, but they will in general refuse to descend further, because of the unwholesomeness of soil where water stagnates, (not to mention the mechanical opposition to their further progress). *Let a dry season come, and their roots having little depth, the plants will be more speedily burned up.* But lower the level at which water stagnates, or remove it altogether by working the subsoil, the rains will then freely wash the subsoil, and the roots will descend into it, so that if a drought come again, it may parch the soil above, as before, without injuring the plants, since now they are watered and fed by the soil beneath.

Digitized by Google

If science never wrote another sentence applicable to our agriculture, the one just quoted from an able pen would be invaluable, if duly weighed and acted upon. Many portions of the State, we are aware, do not require drainage according to the view generally entertained of the word; but there is no doubt that many spots, even those of the finest, might be improved by the judicious introduction of drains, *just to create a circulation through them;* and we feel perfectly convinced that persons act most erroneously and in direct opposition to all reason and science, in refusing to work upon our soil and in forcing our crops to grow in shallow plowed soil, with a subsoil as hard as baked ware, and almost equally as impervious to the tender roots. Once more hear Professor Johnston, for the matter can not be too much enlarged upon: "Enable the water to travel downward, and the air from above will follow it, and take its place among the pores of the soil, carrying to every root the salutary influences it is appointed to bear with it, wherever it penetrates. When this is done, the stiff soil will become mellow, and, when once stirred up to a considerable depth, more universally porous, so that air can make its way everywhere, and the roots can easily extend themselves in every direction. The presence of vegetable matter, whether existing naturally in a soil thus physically altered, or artificially added to it, becomes of double value." To facilitate these beneficial actions, the Professor strongly advises the use of what is called the subsoil plow, which breaks up the subsoil and renders it pervious to the air and water, and still more strongly the process of *deep plowing*, which, in addition to other advantages, "brings up new earth to the surface, thus forms a deeper soil, and more or less alters its physical qualities and chemical composition." But we must leave it to those who think it worth while to pursue the subject (and may they be many), to consult his lectures on Agricultural Chemistry, or his smaller work, the Elements of Practical Chemistry, which will amply repay the outlay and trouble. We can not, however, deny ourself the

Digitized by Google

satisfaction of quoting some remarks of a *practical* man on this subject, not only because of their intrinsic value, but because they show what progress practical men are making in the science of agriculture, and place the stamp of experience on the suggestions and reasonings of the man of science. In an article on the culture of land for wheat, by Mr. Morton (author of an excellent work on soils), in a late number of the *Agricultural Gazette*, it is said, "When land is plowed only to the depth of three or four inches, the active soil is so very limited, that the least change in the weather is injurious to the plants growing in it. The manure, under this system of shallow plowing, forms a layer near the surface; the roots of the plants ramify only through the furrow slice in which the dung is placed, and consequently the plant has but little hold of the ground. Being thus spread out horizontally near the surface, the roots are easily exposed to the weather and its influence; in a dry season the shallow soil, and the manure in it, becomes parched and inactive; in wet weather the roots having but little hold of the ground, a soaking rain and a little wind loosen the plant and it is blown out. In a deeply cultivated soil the plant exerts the whole of its energy at first, in the production of roots, which strike deeply into the soil, filling the whole of it with their minute fibers.

"Upon the arrival of genial weather, the organs of the leaves being excited are prepared for vigorous and luxuriant growth; and a wide field having been laid under cultivation for the purpose, the roots easily provide the nourishment required to support them under it. If, under such a system, a plant be pulled up, it will be found that the roots have ramified so extensively that *no variation of temperature can affect them:* they draw their nourishment from sources beyond the influences of the variableness of external agents. Thus, deep cultivation, by encouraging depth of rooting, effects indirectly for the plant a comparative independence of the weather, but it has a direct influence in the same direction, for if the weather be wet, the water more readily passes down to the

Digitized by Google

drains, and *if it be dry, it retains for a longer time a sufficiency of moisture.* Of two crops equally luxuriant in their growth, that is not so liable to lodge which is grown on the deeper soil; for its growth has been more gradual and natural, and less the result of artificial excitement. Of course, it must be understood that *deep* cultivation can safely be entered upon only in soils that are naturally or artificially *dry.*" This last is a precaution more necessary to be given in England than with us; but altogether, though authorities might be multiplied on this head to an almost indefinite extent, yet we should hardly find anything more applicable to our case or more clearly expressed. We would recommend the careful perusal of the fifty-second section of Mr. Morton's valuable work on soil, where the subject is clearly treated and its advantages strongly put.

It will not be amiss to quote one short sentence from Liebig on this subject: "In hot summers," says he, "accompanied by light and partial showers of rain, *porous* soils of no great fertility yield often better crops than richer stiff soils. The rain falling on the porous soil is immediately absorbed and reaches the roots, while that falling on the heavy soil is evaporated before *it is able* to penetrate them."

Drainage improves the quality of crops. In a dry season, we frequently hear the farmer boast of the quality of his products. His hay-crop, he says, is light, but will "spend" much better than the crop of a wet season; his potatoes are not large, but they are sound and mealy. Indeed, this topic need not be enlarged upon. Every farmer knows that his wheat and corn are heavier and more sound when grown upon land sufficiently drained.

Drainage prevents drought. This proposition is somewhat startling at first view. How can draining land make it more moist? One would as soon think of watering land to make it dry. A drought is the enemy we all dread. Professor Espy has a plan for producing rain, by lighting extensive artificial fires. A great objection to his theory is, that he can

Digitized by Google

not limit his showers to his own land. and all the public would never be ready for a shower on the same day. If we can really protect our land from drought by underdraining it, everybody may at once engage in the work without offense to his neighbor.

If we take up a handful of rich soil of almost any kind, after a heavy rain, we can squeeze it hard enough with the hand to press out drops of water. If we should take of the same soil a large quantity, after it was so dry that not a drop of water could be pressed out by hand, and subject it to the pressure of machinery, we should force from it more water. Any boy who has watched the process of making cider with the old-fashioned press, has seen the pomace after it had been once pressed apparently dry and cut down, and the screw applied anew to the "cheese," give out quantities of juice. These facts illustrate, first, how much water may be held in the soil by attraction. They show, again, that more water is held by a pulverized and open soil, than by a compact and close one. Water is held in the soil between the minute particles of earth. If these particles be pressed together compactly, there is no space left between them for water. The same is true of soil naturally compact. This compactness exists more or less in most subsoils, certainly in all through which water does not readily pass. Hence, all these subsoils are rendered more permeable to water by being broken up and divided; and more retentive by having the particles of which they are composed separated, one from another—in a word, by pulverization. This increased capacity to contain moisture by attraction, is the greatest security against drought. The plants in a dry time send their rootlets throughout the soil, and flourish in the moisture thus stored up for their time of need. The pulverization of drained land may be produced, partly by deep or subsoil plowing, which is always necessary to perfect the object of thorough-draining; but it is much aided in stiff clays, also, by the shrinkage of the soil by drying.

Digitized by Google

Drainage resists drought, again, by the very deepening of the soil of which we have already spoken. The roots of plants, we have seen, will not extend into stagnant water. If, then, as is frequently the case, even on sandy plains, the water-line be, in early spring, very near the surface, the seed may be planted, may vegetate, and throw up a goodly show of leaves and stalks, which may flourish as long as the early rains continue; but suddenly, the rains cease; the sun comes out in his June brightness; the water-line lowers at once in the soil; the roots have no depth to draw moisture from below, and the whole field of clover, or of corn, in a single week, is past recovery. Now, if this light, sandy soil be drained, so that, at the first start of the crop, there is a deep seed-bed free from water, the roots strike downward at once, and thus prepare for a drought. The writer has seen upon deep-trenched land in his own garden, parsnips which, before mid-summer, had extended downward three feet, before they were as large as a common whiplash; and yet, through the summer drought, continued to thrive till they attained in autumn a length, including tops, of about seven feet, and an extraordinary size. A moment's reflection will satisfy any one that the dryer the soil in spring, the deeper will the roots strike, and the better able will be the plant to endure the summer's drought.

Again, drainage and consequent pulverization and deepening of the soils increase their capacity to absorb moisture from the atmosphere, and thus afford protection against drought. Watery vapor is constantly, in all dry weather, rising from the surface of the earth; and plants, in the day-time, are also from their leaves and bark, giving off moisture which they draw from the soil. But Nature has provided a wonderful law of compensation for this waste, which would, without such provision, parch the earth to barrenness in a single rainless month.

The capacity of the atmosphere to take up and convey water, furnishes one of the grandest illustrations of the

Digitized by Google

perfect work of the Author of the Universe. "All the rivers run into the sea, yet the sea is not full;" and the sea is not full, because the numerous great rivers and their millions of tributaries, ever flowing from age to age, convey to the ocean only as much water as the atmosphere carries back in vapor, and discharges upon the hills. The warmer the atmosphere, the greater its capacity to hold moisture. The heated, thirsty air of the tropics drinks up the water of the ocean, and bears it away to the colder regions, where, through condensation by cold, it becomes visible as a cloud; and as a huge sponge pressed by an invisible hand, the cloud, condensed still further by cold, sends down its water to the earth in rain.

The heated air over our fields and streams, in summer, is loaded with moisture as the sun declines. The earth has been cooled by radiation of its heat, and by constant evaporation through the day. By contact with the cooler soil, the air, borne by its thousand currents gently along its surface, is condensed, and yields its moisture to the thirsty earth again, in the form of dew.

At a Legislative Agricultural Meeting, held in Albany, New York, January 25th, 1855, "the great drought of 1854" being the subject, the Secretary stated that "the experience of the past season has abundantly proved that thorough-drainage upon soils requiring it, has been proved a very great relief to the farmer;" that "crops upon such lands have been far better, generally, than those upon undrained lands in the same locality;" and that, "in many instances, the increased crop has been sufficient to defray the expenses of the improvement in a single year."

Mr. Joseph Harris, at the same meeting, said, "An under-drained soil will be found damper in dry weather than an undrained one, and the thermometer shows a drained soil warmer in cold weather, and cooler in hot weather, than one which is undrained."

Digitized by Google

The Secretary of the New York State Agricultural Society, in his report for 1855, says: "The testimony of farmers in different sections of the State, is almost unanimous, that drained lands have suffered far less from drought than undrained." Alleghany county reports that "drained lands have been less affected by the drought than undrained;" Chatauque county, that "the drained lands have stood the drought better than the undrained." The report from Clinton county says: "Drained lands have been less affected by the drought than undrained." Montgomery county reports: "We find that drained lands have a better crop in either wet or dry seasons than undrained."

B. F. Nourse, of Orrington, Maine, says that on his drained lands, in that State, "during the drought of 1854, there was at all times sufficient dampness apparent on scraping the surface of the ground with his foot in passing, and a crop of beans was planted, grown and gathered therefrom, without as much rain as will usually fall in a shower of fifteen minutes' duration, while vegetation on the next field was parching for lack of moisture.

A committee of the New York Farmers' Club, which visited the farm of Prof. Mapes, in New Jersey, in the time of a severe drought in 1855, reported that the Professor's fences were the boundaries of the drought, all the lands outside being affected by it, while his remained free from injury. This was attributed, both by the committee and by Prof. Mapes himself, to thorough-drainage and deep tillage with the subsoil plow.

Mr. Shedd, in the *N. E. Farmer*, says:

"A simple illustration will show the effect which stagnant water, within a foot or two of the surface, has on the roots of plants.

"Perhaps it will aid the reader who doubts the benefit of thorough-draining in a case of drought, to see why it is beneficial.

Digitized by Google

SECTION OF LAND BEFORE IT IS DRAINED.

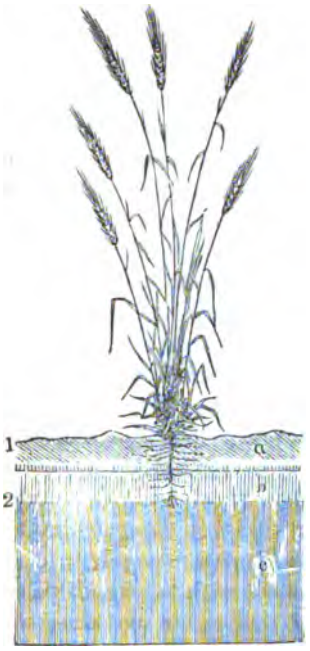


FIG. 25.

SECTION OF LAND AFTER IT IS DRAINED.

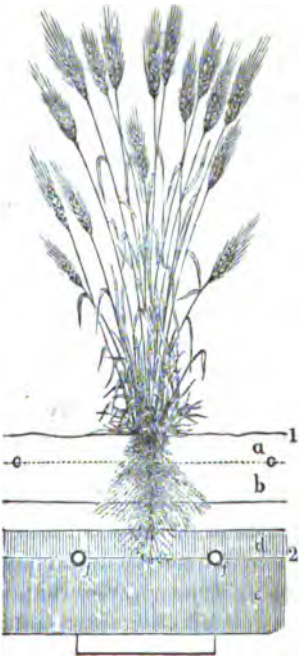


FIG. 26.

"In the first figure, 1 represents the surface-soil, through which evaporation takes place, using up the heat which might otherwise go to the roots of plants; b, represents the water-table, or surface of stagnant water below which roots seldom go; a, water of evaporation; b, water of capillary attraction; c, water of drainage, or stagnant water.

"In the second figure, 1 represents the surface-soil warmed by the sun and summer rains; 2, the water-table nearly four feet below the surface—roots of the wheat plant have been traced to a depth of more than four feet in a free mold; d, water of capillary attraction; e, water of drainage, or stagnant water."

Digitized by Google

Seeding.

After the ground has been properly prepared for seeding, the next thing to be done is to select the best and cleanest seed wheat. The best variety should always be obtained even at a price double the usual selling price. Almost every farmer has some special manner of selecting seed; some by threshing the sheaves with a flail, others by *tramping* it out with horses. But whatever kind of wheat you use for seed, be sure it is entirely free of foul seeds. A good way to get seed wheat is, to take ripe sheaves and beat off the best of the grain in an open barrel or tierce, leaving the smaller grains still in the head for the thresher. Then take this picked seed, winnow and screen it well, and you have the cream of the field.

We may by some be deemed over-nice in our views, but we would recommend, wherever it is practicable, that the largest and plumpest berries be selected by hand-picking. We are satisfied that the farmer who does so *once* will find his own reward in the result.

A habit has obtained among the European population, more especially among the Germans and French in Stark, Holmes, Wayne and Columbiana counties, to soak the seed wheat over night in a solution of blue vitriol, say one pound to five or six gallons of water into which as much wheat is poured as the water will cover. They gave us various reasons for this practice, among which the following were the most prominent:

I. That soaking the wheat killed the Hessian fly.

II. That soaking the wheat killed the midge.

III. That soaking the wheat prevented smut.

IV. That soaking the wheat caused it to tiller more than double the usual amount.

How far practice confirmed the hypothesis we have no certain means of determining, but certain it is that these farmers always were rewarded with abundant crops of excellent wheat.

In addition to steeping the wheat seed, some subjected it to another process. After it was removed from the steep quick-

Digitized by Google

lime was sprinkled over the mass, and so thoroughly incorporated in it that each individual seed was completely covered with lime.

We by no means object to seed being steeped, well satisfied that it more thoroughly cleanses the seed of all parasites and other impurities with which it may be contaminated, but deem it our duty at the same time to state candidly and explicitly, that we do not believe that steeping accomplishes all that is claimed for it.

I. That it kills the Hessian fly is obviously a mistake, because to kill it by steeping presupposes that the larvæ of this parasite already exist in the grain of wheat; we have searched through many grains of wheat grown in the fields affected by the Hessian fly, and have been unable to find any orifice by which they could have entered, neither could we find any larvæ in the body of the grain.

II. The same objection is equally valid with respect to the midge.

III. There is no doubt that steeping and liming, if thoroughly done, will effectually prevent smut.

IV. We must be pardoned for our inveterate scepticism with respect to the doctrine that steeping will augment tillering. If this hypothesis were correct, then steeped seed, if sown on a barren soil, would tiller as profusely as if sown on a rich one. But we have another equally strong objection to this hypothesis, viz.: we do not believe that any solution will add vigor or prolificacy to the plant, but admit that chemical and mechanical conditions of soil can produce such results.

Having prepared the ground and selected the seed, the next thing in order is to get the seed properly placed in the soil. We confess our partiality to the drill, and can not present the arguments in favor of the drill more concisely and effectually than they are stated in the following prize essay copied from the *Ohio State Agricultural Report*, for 1858:

"The present century will be more distinguished in the history of agriculture than any of its predecessors, for imple-

Digitized by Google

ments designed to economize the time and labor of the husbandman; but the credit of machines for seed planting does not belong to it. They were known to the Italians in the beginning of the seventeenth century. Experiments in Italy, about the year 1650, with machines having a cylinder in a seed box, arranged over plows, on wheels, in the language of an ancient chronicler, "brought a crop of sixty for one." This success introduced the machines to Spain in 1669. In the beginning of the seventeenth century, according to Bacon, attempts were made in England to plant wheat by machinery. The experiments were abandoned because the machines being rude, the method was considered too laborious, but against the judgment of the farseeing philosopher who declared it advantageous. Later in the seventeenth, and early in the eighteenth century, various attempts were made to gain successes which would secure general favor for seed-planters; but not until the beginning of the nineteenth century did drilling become at all common in England. Machinery is now commonly employed there, not only for planting wheat and other grains, but for turnip and other root seeds. Drills have been used chiefly in America for planting corn and wheat, and for sowing grass seed. Their service for those purposes was not known among farmers, generally, ten years ago.

Since 1850, wheat planters have been more and more widely employed in Ohio and other wheat-growing States, and will, in a few years, entirely supersede the hoe and the harrow, for practical reasons, which may be set forth in three propositions:

It is better to plant wheat with a good drill than to sow it broad-cast and harrow it in, because,

Time and labor are economized,

Seed is saved,

A larger yield is secured.

Why Labor is Saved.

I. Supposing the ground to be alike prepared for broadcast or drill seeding, the farmer can "put out" two acres with a

Digitized by Google

good drill for every one he can broadcast and harrow in. Sixteen acres a day is not a large claim for a drill, on good ground, with a pair of tractable horses and an attentive driver. But, the saving of three or four, or six or eight days' labor in a year, is not the great advantage in the economy of time and labor gained with a drill. It is the saving of time at a favorable juncture for planting—the accomplishment of a large amount of work when the necessity is most imperative.

Again, when the farmer drills his grain, the work is finished as fast as his team goes across the field. Not so, when he scatters his seed broadcast. A sudden storm, or some other contingency, may arrest his labors, when only a part of the seed has been harrowed in, and he may be obliged to sow over it again to his disadvantage, not only in the labor and seed expended, but, perhaps, to the detriment of the expected crop.

Why Seed is Saved.

II. One and a quarter bushels of seed planted with a drill are equal to one and a half bushels sown broadcast, under the same circumstances of soil and climate, because all the grain put into the drill-box is deposited in the ground—none is blown away—none is left where the birds can pick it up, or the common insects can feed upon it.

Again, independently of loss of seed by failure to find a lodgement for it in the soil when broadcast, seed is saved by the drill, because the precise quantity known to be most desirable can always be sown.

Why a Larger Yield is Secured.

III. Wheat drilled produces more abundantly than that sown broadcast, for the following reasons:

1. The shovel of the drill removes small stones and pulverizes the soil, at least enough to allow fine dirt to fall over the seed, which is thus better placed for vegetation than it

Digitized by Google

can be with a harrow that partially stirs it with the soil, leaving some seeds too deep, some not deep enough, and others entirely uncovered.

2. The shovel of the drill makes a furrow, at the bottom of which the seed is covered; the earth thrown out on either side of that furrow forms a drain, in which the water carries all the better properties of the soil, nourishing the roots of the grain. When spring comes, the frosts which have "thrown out" and winter-killed broadcast wheat, having filled the drains in the drilled field, its roots are in good soil well fed, and at once the wheat grows vigorously. The frosts, therefore, which are disadvantageous to broadcast wheat, have a good influence upon that properly drilled.

3. The seed deposited by the drill, at whatever depth the farmer may wish, according to soil, climate, or season, having taken root with an even, firm hold, produces a vigorous blade, and induces healthy tillering. In time of drouth, the grain grows steadily, while much of that sown broadcast, in soil of the same character, shrivels, or produces single weak stalks, because the evaporation has taken the moisture out of the ground where its roots lie.

4. The position of drilled wheat is favorable to the circulation of light and air, elements which are known to be intimately required for healthful growth and proper ripening, by every stalk.

5. The growth of drilled wheat being uniform, from the fact of its regular distribution at regular depth, its ripening is nearly simultaneous, and it is, therefore, not subject to the ravages of the midge (yellow weevil), or to damage by rust, in the same degree that broadcast wheat is; some stalks of which, as is well known to farmers, may be in blossom, while in others the grain is hardening, thus affording the mischievous insect fair opportunity to make sad havoc—giving it time to work upon heads in different parts of the field, just when it can be most destructive.

6. Ripening uniformly, because all its stalks have had equal

Digitized by Google

nourishment from soil, moisture, light and air, drilled wheat may be gathered with greater security than broadcast, in which there may be heads too ripe, while others are barely fit for harvest.

7. Having depth of root—having grown regularly, because uniformly nourished and protected, drilled wheat produces strong stalks which bear large heads. Experience has proven that when wheat stalks are crowded together, they produce heads of different sizes, very small, and poorly filled. It is impossible to guard against irregular planting, with the hand and the harrow, and it is possible to make an even distribution of seed with good machines, properly adjusted; therefore have experiments, made with care, demonstrated the fact that the yield from drilled wheat is on an average one-fifth greater than from that sown broadcast. A careful man who examines a field of wheat, will find that the stalks which bear small heads, have roots that lie near the surface of the ground; those bearing large heads have roots lying not less than two, and in many soils, three inches deep. If the seeds well planted are those which bear large heads, to plant all the seeds well will, under ordinary circumstances, secure large heads on all the stalks. Therefore is it clear why forty-eight bushels of wheat per acre have been harvested from fields when drilled, which when sown broadcast, did not average forty bushels per acre.

SUMMARY.

The whole question of the comparative advantages of drill seeding, over broadcast, may be resolved into three plain statements:

1. Wheat sown broadcast is at the mercy of the winds, the harrow, the birds, the insects, and the clouds.

2. No intelligent farmer will deny that careful experiments will decide exactly what depth for given soil, seed ought to be deposited; and exactly how much to the acre will grow well and produce best under known conditions.

Digitized by Google

3. Then, the proper quantity of seed to the acre ascertained —the proper depth discovered—it is obvious that the instrumentality by which the quantity desired will be uniformly deposited at the depth desired, should always be employed when wheat is to be planted.

Now, the question arises: Can farmers procure, at reasonable cost, machines for planting wheat, which will deposit the seed at regular distances, and at uniform depth? That either of the drills offered by the State Board of Agriculture as prizes, is capable of answering what this essay demands for a good machine, many reliable certificates can be adduced.

It should be mentioned as an incidental advantage of drills, that to several of the different machines grass-sowers are so attached, that while the grain from one box is being planted in drills, grass seed is sown broadcast from another. Not only does wheat grow better in drilled fields, but the grass sown in them is better than that cultivated with broadcast wheat, because through the regular grain, light and air, and dews, and gentle rains more directly reach it.

Another incidental advantage of drill seeding may be suggested—that of depositing special manures with seed.

The foregoing arguments—which might be strengthened with minor points that will suggest themselves to thoughtful farmers—are not based upon speculation, but upon actual experiments, through a series of years, to which, if required, certificates of as good farmers as there are in Ohio, can be obtained.

Good drills, in Ohio, cost from $75 to $100. Whether their advantages justify such an outlay, is answered in the reasons I have given why they save seed and labor, and secure increased crops. I can give the name and address of more than one prominent farmer who will certify that the increase of crop for drilled, over broadcast wheat, was worth enough in one year, from forty acres, to pay for a drill which cost $75.

But drills are not alone economical for the planting of wheat. They have been proven advantageous for oats, barley,

Digitized by Google

rye, and corn, and may be used in America, as in England, for planting beans, peas, and the seeds of other vegetables, wherever their cultivation, on a large scale, is undertaken.

I might close this essay with tabular statements contrasting, in support of my propositions, the labor, expense, and profit of broadcast and drill seeding, but I will omit them because I do not think the candid inquirer will demand more particularity than has been given.

When the validity of my claim, for economy of labor and seed by means of a good drill; and for an average yield one-fifth larger than hand and harrow seeding secures, is respectably disputed, statistics supporting it, from the best wheat growing districts in the Western country, will be produced.

Effects of Warmth and Frost upon Plants.

When the agriculturist has entrusted the seeds to the bosom of the earth, he has done, with few unimportant exceptions, all that he possibly can do toward securing the perpetuity of the plant. The growth of the plant depends upon the proper amount, and at seasonable periods, of sunshine and rain. Both warmth and moisture are of equal, as well as of prime importance in the germination of the seed, and the development of the future plant. If the one condition is not fulfilled, it can not be supplied by the other. No amount of rain can supply a deficiency of sunshine; and all the sunshine possible can not make good the want of rain; heat without rain is just as fatal as rain without warmth.

It may appear superfluous to spend either time or words in the investigation of a subject over which man has no absolute control; but as investigation has been commenced, we learn, the further the subject is pursued, that notwithstanding we can not control the operation of the elements, we may nevertheless so accommodate ourselves to their operation as to leave their effects less disastrous.

We shall allude to several well known phenomena only to illustrate this declaration. There are fields often in the same

Digitized by Google

vicinity upon which the sun shines equally, but which are nevertheless warmed in unequal degrees; the practical agriculturist says of the soil in one field that it is cold, and of the other that it is warm; and it is a well known fact that the cold soil never produces as abundantly nor as luxuriously as the warm soil. The cold soil is generally composed of impervious substances, which retain moisture a great length of time. Now by thoroughly underdraining a cold soil, the plant is greatly benefited, not only by not having a superfluous amount of subterranean water to contend with, but also by the increased temperature of the soil consequent upon the removal of the water. The rays of the sun then produce actual warmth in the soil, while before it was drained, they served to evaporate moisture only.

Again: a cold soil is most generally a light colored one. It is a well known law in nature that dark objects attract and retain rays of light better than light colored ones; hence, if a light colored cold soil can have a dark substance, as humus, soot, etc., incorporated with it, it will become warmer.

There are many practical questions depending upon the solution of the temperature of the soil; one of which we will present, without attempting a solution of it, viz.: What temperature of soil and atmosphere are most appropriate in which to sow seeds? For example, is it better to plant ripe potatoes in a low temperature, or to plant later, when both soil and air are warmer? The recent investigations in the search of the cause of the potato rot, as well as the cause of Honeydew and Mildew, demonstrate that they are caused chiefly by sudden changes of temperature between high and low ranges. The theory that potatoes planted very early, and suffered to lie in the soil without germinating, and subject to many changes, if not extremes of temperature, are more subject to disease than those planted later, is not without foundation in fact. It has frequently been observed that late planted potatoes have not outstripped the early planted ones in growth, but have produced much healthier fruit.

Digitized by Google

Notwithstanding we may be able to explain the operation of the sun's rays upon soils and plants in some special cases, yet there are so many relations which warmth sustains to the plant that every reflecting person has asked himself the question, "How is this to be explained? Why is it?" We will endeavor to explain the effects of dew, frost and freezing upon plants. Dew has frequently been observed in one locality, while in the same neighborhood perhaps a frost has occurred; in one place a plant is found to have been frozen, while in another the plants are fresh and healthy; here leaves on the top and side only of a tree have been frozen, while on the other side and beneath they were not affected, etc.

Inherent Warmth of Plants, and the Warmth they Receive from the Sun.

If we admit that plants, like animals, through vitalization, have the power to generate warmth, we must at the same time be convinced that they are subject to all the fluctuations of temperature that the atmosphere which surrounds them, and the soil in which they grow are subjected to. In order to demonstrate this dependency experiments have been instituted to determine the temperature of the heart of the trunk, limbs, and even roots of trees, by inserting a thermometer, and then comparing it with one registering the temperature of the air which surrounded it. The results exhibited a great disparity in temperature.

An observation made on a maple in midsummer resulted as follows:

Temperature of the atmosphere	74° F.
" in the heart of the trunk, 12 inches in diameter	58°
" of the sap wood of trunk	62°
" of the heart of upper portion, 6 inches in diameter	71½°
" of a three inch limb	72°
" of a root at nine inches depth	59°
" of the soil	58°

The relation which the plant, atmosphere and soil bear to

Digitized by Google

each other, so far as warmth is concerned, is more apparent during sudden changes of temperature. The observations above mentioned were repeated on the same tree at a time when, in the course of seven hours, the temperature of the atmosphere rose from 6° to 41°; during the same period the temperature of the limb rose from . . . . 16½° to 41°

" of the trunk, 6 inches in diameter 15° to 33°

" of the trunk, 12 inches in diameter 16½° to 25°

" of sap-wood . . . . . 33° to 34°

From this it is very evident that the young and tender portions of the plant are more subject to the vicissitudes of temperature than the older and more woody portions—the older parts acquire and impart temperature with much less rapidity than the younger portions, which are affected by the slightest changes. This experiment, however, affords no evidence of innate warmth in the plant. The question whether plants can generate heat was first determined by the fact, well known to our nurserymen, that if plants are surrounded by vapor they "*damp off.*" From this phenomenon we conclude that plants have an inherent warmth, because water can be converted into and remain in vapor only, when confined in a space already saturated with moisture, and under a rising temperature;—if, therefore, when plants situated in a place saturated with vapor without a rising temperature, or a temperature to sustain it in vapor, still exhale moisture, it is very evident that the heat necessary to convert the water into vapor must be produced by the plant itself. The temperature of all plants is not, however, the same, but their capacity to exhale depends upon the amount of leaf surface.

But as the innate warmth of the plant appears to be applied only to convert the water into vapor in order to exhale it, it therefore becomes more explicable why plants are subject to all the changes in temperature which the soil and atmosphere undergo.

The absolute heat of plants, like that of all inanimate substances, is dependent upon the action of the rays of the

Digitized by Google

sun, the physical laws of which are well known, namely, transparent, brilliant and light-colored substances do not retain the heat, but substances which are rough and dark absorb and retain the heat of the sun. That the power of substances to retain heat depends upon their color is readily demonstrated. Professor Schnebler covered some earth with a coat of talk or white earth, and another portion with soot. In the course of an hour that under the white cover exhibited a temperature of 93½°, while that under the black was 104°.

Plants having large and deep-green leaves one would naturally suppose would in consequence be warmer than the atmosphere, but strict observation has determined that they are absolutely colder—the heat being almost exclusively devoted to evaporating the moisture.

When the sun's rays no longer fall upon the plants, as in the evening just after sunset, then the plant gradually cools down, and imparts all the warmth it had acquired during the day. The rapidity with which plants part with their warmth is very dissimilar, although the plants themselves are similarly, or even alike situated. As a general thing, plants whose leaves are thin, serrated, or hairy, part more readily with warmth than those having thick, fleshy, and smooth leaves. The precise amounts of depression of temperature to which certain plants are subject are well known—a blade of rough grass, for instance, loses from 12° to 15° of warmth, while a camelia leaf parts with no more than from 6° to 9°.

Another phenomenon of the radiation of heat is the formation of dew. Dew is formed on objects which are in contact with the atmosphere, and have imparted the warmth which they acquired during the day to it; and, as they gradually lose their warmth, so also do they lose their capacity to retain water in the form of vapor, and consequently by their want of warmth they condense the moisture of the atmosphere, which is found in the form of small globules or drops on the surface of these substances; upon the same principle that drops of water collect on the outside of a glass vessel filled with cold

Digitized by Google

water on a warm day. Dew does not fall every evening, and even when it does fall it is not observed on all objects or substances. Dew falls only when the sky is serene and the air is calm; then just before sunset, if there are substances on which the rays of the sun are no longer falling, they will be found to be moist. If the sky is clouded the radiation of heat is interrupted, and of course condensation can not take place. If we suspend a board or stout paper over a plant, the heat which it radiates is thrown back upon it, and thus is the plant kept warm—the temperature is not reduced in consequence to the dew point—hence there is no dew in a dense forest, neither is there dew in the immediate vicinity of walls, buildings, etc., because they radiate during the entire night in summer time. A very gentle breeze will prevent dew from forming, because every moment the atmosphere is changing, and this interrupts radiation.

If we examine objects in the morning after a dew has fallen we discover that although substances are lying in close proximity to each other, they yet have unequal amounts of dew upon them; metallic substances having the largest amount, wooden ones less, etc. If plants are examined, it will be found that the leaves of some contain much more than others of the same superficies. This phenomenon is in accordance with a law of nature, that rough, or uneven, or pointed bodies radiate their heat more rapidly than those with smooth or polished surfaces. The former radiating more rapidly are cooled more rapidly, and condense more rapidly than the latter. Grasses therefore have more dews, in proportion to the superficial area, than other plants. Hence bearded wheats have more dew than bald or smooth ones, and as frost is nothing more nor less than frozen dew, it follows, as a matter of course, that bearded wheats when in head suffer more from frosts than smooth ones. The frost of June 4, 1859, fully demonstrates this fact, if any proof were necessary. The Mediterranean everywhere suffered more from the frosts than did the white blue-stem.

Digitized by Google

Again, there is a very great difference in the capacity of bodies to retain heat, and much more heat must consequently be applied to produce in such bodies the same temperature: water, for example, requires thirty-three times as much heat to raise its temperature to 200° as mercury does. The body possessing the greatest capacity for retaining heat imparts it the slowest, and therefore collects less dew than those which impart heat rapidly—hence limestone and quartz seldom collect dew, and for this reason sandy districts have very little dew but great heat and drought.

When the temperature of the atmosphere falls below 32°, the dew congeals as rapidly as it falls, and it is called frost. It not unfrequently happens that in valleys there is a frost, when places having a greater elevation have dew only—or that grass is frozen while cabbage is bedewed only.

It frequently happens that grass is frozen while at a place fifteen or twenty feet above it dew only has formed. The grass has been deprived of the sun's rays sooner than the higher object, and the cold atmosphere obeying the law of gravity, has sunk down in the valley, and remained calm.

The radiation of heat from plants produces the phenomenon at which we have intimated above, namely, frost or freezing of plants at certain seasons of the year. Frosts from radiation occur most generally in spring and autumn, although they sometimes occur in June, and even in July and August, during nights when the sky is bright and clear, and other conditions favorable for rapid radiation. The temperature of the atmosphere at the surface of the earth, must then be one or more degrees below 32°, or freezing point. These summer frosts present peculiar phenomena—in deep valleys, on banks, and on streams frost may be found, while the uplands will have dew only; two or three spots in a twenty-acre field may be affected by frost, while the remainder of this escaped uninjured. Then, again, plants which radiate fully or rapidly may be frozen, while those which radiate slowly may escape entirely. In some fields in which bearded and

Digitized by Google

smooth wheat were sown but not thoroughly mixed, the places in which the bearded variety preponderated was frozen, while such portions as contained a greater proportion of smooth than bearded was only slightly frozen.

The Grass family (and wheat is a member of this family) is more subject to frost than any other family of plants—this susceptibility to frost is so remarkable that there is scarcely a meadow of any considerable extent in which frost may not be found during every month in the year. Every nurseryman has learned, by sad experience, that it is more difficult to rear young plants in a grass plat, on account of frost, than it is on a plat enjoying regular plow culture. If there are two vineyards adjoining each other, the one suffered to grow in grass while the other is kept clean, should a frost occur the grassy vineyard will suffer the most severely.

It is a common practice with German gardeners to sprinkle water profusely over the plants which are frozen before the sun has an opportunity to shine on them. If the frost was severe the water will be congealed, while at the same time it thaws the plant, or takes the frost out of it. Observation teaches that if a rain follows a frost without the intervention of sunshine, the plants are uninjured; but if sunshine follow the frost, whatever it has touched is generally fatally injured.

It is an error to suppose, as was formerly done, that when frozen plants are sprinkled with water, they are thereby more gradually thawed than by the sun's rays. It is well known that water expands as it is converted into ice, and not unfrequently increases one-tenth in bulk, and from this fact it has been inferred that the juices in the cells of the plant ruptured their envelop; but it is found that the cells are not uniformly ruptured, most generally they are expanded only.

In freezing air becomes separated from the water, and it is very seldom indeed that a piece of ice can be obtained entirely free from little cavities filled with air. Now, if the

Digitized by Google

frozen cells of a plant are examined, they will be found to contain minute cavities of air; this free or separated air does not combine with the water when the plant thaws, but remains separate, and acts destructively on the chlorophyll, and destroys the vitality of the plant. In order, then, to prevent the separated from acting on the plant, if water is poured over it, it will absorb or drink in the water, fill the cells therewith, and expel the air through the ducts of the plant. The stimulant thus furnished the plant incites it to activity and prevents the action upon the chlorophyll. If apples or potatoes are frozen and prepared for the table while in this condition, they are not injured in texture or flavor. Hard frozen potatoes, if plunged into a pot of boiling water, are cooked as "*mealy*" as if they were not frozen; but if suffered to thaw and then cooked, they never become mealy, and have invariably lost much of their flavor. If potatoes, when frozen, are thawed in cold water, the frost is drawn out without any injury to any of the qualities. So also of apples.

Acting upon the suggestion indicated by nature that a strong light was injurious to frozen vegetables, a friend of mine (Mr. Gribble, of Cleveland) having had some potatoes and apples frozen in his cellar in the severe winter of 1855–6, placed them immediately in utter darkness, where no ray of light could reach them—in the spring they were found thawed and in excellent condition—in fact it was difficult to determine whether they were frozen at all. Hence it is possible that if garden vegetables are frozen during the night, and are covered early in the morning, so as to exclude the light of the sun, the freeze they have undergone will not injure them. It is, to say the least, worthy of experiment.

How the frost acts, or what physical and chemical changes a plant undergoes in freezing, is not so clearly described by writers on this subject as is desirable to a perfect comprehension of the subject. On a previous page it was suggested that in all probability the action of light on plants was to fix the carbon, while the oxygen was permitted to escape; and at

Digitized by Google

night, when the light was withdrawn, there being nothing to fix the carbon, it then escaped, or, in other words, that the plant exhaled oxygen during the day-time, and carbon or carbonic acid at night. Should future investigations confirm this suggestion, may not the following be, perhaps, an explanation of the manner in which frost acts:

The plant receives its nourishment in a fluid form, which is composed chiefly of carbonic acid, oxygen, hydrogen, and nitrogen. When plants freeze, the cell-walls, or membranes are expanded from the expansion of the fluids contained within them, because it is a well known law, that freezing causes fluids to expand;—almost every one is familiar with instances of bottles containing water being burst by freezing. Now, the cell-walls in plants, fruits, etc., are exceedingly delicate, and attenuated to the highest degree, and in the normal state are filled with parenchyma, or fluid matter from which wood, starch, sugar, gum, etc., are formed. All these substances, namely, wood, starch, sugar, gum, etc., contain carbon combined with oxygen and hydrogen. When freezing ensues the combination is probably separated; the oxygen and hydrogen (water) eliminated, and the carbonic acid retained; then, when light, and necessarily heat is suffered to act on the plant in this condition, the carbon becomes fixed in the cells, and impedes the circulation of newly elaborated juices, sent up from the roots. The regular channels are, if not absolutely obliterated, at least obstructed by an abnormal mass of matter, and the plant necessarily dies. But if light is withheld, there is no separation of the carbon from the other elements, the combination is not deranged or disturbed, and the accumulation of new juices sent up by the roots commingles with that the progress of which had been arrested; a re-organization of the cell-contents takes place, and the elaboration of the juices preparatory to being converted into wood, starch, sugar, etc., goes on as before.

The wheat plant is a hardy plant, and has more vitality and recuperative energy than most of cultivated plants. Wheat

Digitized by Google

sown in the fall is seldom killed by the severest winter frosts, but oats sown in the fall are killed by almost the first frost of winter. In the spring time wheat may be pastured or mown down with no other injury than that of being retarded a few days at harvest. There are very few plants which possess such vitality.

Many frosts have occurred in May and June, of different years, which destroyed beans, cucumbers, tomatoes, and other garden vegetables, but which did not injure the wheat. The early frosts in May, 1845, retarded the wheat; but they occurred before it had headed out. Many ascribed the short heads to the frost, when in reality it should have been ascribed to the great drought which then prevailed. The frost of the 29th of May, 1845, destroyed the wheat which was in bloom at that time, while that which had not yet bloomed, and that in which the berry was partially formed, escaped. That which was killed in bloom sent out new tillers, and in many instances produced a considerable amount of wheat late in the season—say in the latter part of August and first of September. It is perhaps to be recommended, in cases where wheat is killed in the bloom, to leave the field undisturbed; let the plant put forth new tillers, or stools, and in all probability as profitable harvest will be obtained as any other which could be grown on the same tract during that season.

When Should Grain be Harvested.

When is the proper period to cut grain? This is an important question with the Western farmer at the present moment; for it is one closely allied to his interests, and one which he should carefully inquire into. The best means of deciding the question is to consult the opinion of those, who, by a course of careful experiments, have acquired such experience as entitles their decisions to respect. The weight of opinion seems to be decidedly in favor of early harvesting—before the grain is fully ripe. The most judicious millers and grain dealers are decidedly in favor of early harvesting—and

Digitized by Google

certainly their opinion is worth something. In New York, and indeed, in all of the great grain-growing States, the practice of cutting grain before it is dead ripe, universally prevails. With them, the exact time when it should be cut is now no longer a matter of doubt; all being perfectly convinced that the right period is indicated by that change which the grain experiences when passing from a milky state to that of complete hardness; or, in other words, when it is in the "dough," and when the kernels without being "sticky," are yet not sufficiently hard to resist the pressure of the thumb and finger.

The advantages of this early cutting are: The grain is heavier, plumper, sweeter and whiter—thereby making it more valuable for the market; there is less loss from scattered grain, either from the high winds, or when the grain is cut with a machine, or in handling when stacking; the straw, particularly when it is an object to feed, is much more valuable, because it will possess a greater proportion of succulence and saccharine sweetness, which render it better food for stock; the farina of the grain being perfected, all that is necessary to render it fit for flouring is the hardening of it, and this, it is abundantly established, may be as well perfected after the straw is cut, as before. Again, grain that is allowed to stand until it is fully, or dead ripe, makes darker flour.

Many experiments in cutting wheat at different periods of ripening, go to show that from twelve to fourteen days before "dead ripe," gives the plumpest, heaviest, thinnest skinned, and most nutritive grain. The loss in weight by standing is nearly 15 per cent., and the loss in equal weights by the increase of bran, is about 4 per cent. At this period the grain is in the milk; "there is," says the late Prof. Norton, "but little woody fiber; nearly every thing is starch, gluten, sugar, etc., with a large percentage of water. If cut then the proportion of woody fiber is still small: but as the grain ripens the thickness of the skin rapidly increases, woody fiber being formed at the expense of the starch and sugar; these must

Digitized by Google

obviously diminish in a corresponding degree, the quality of the grain being of course injured."

Early cutting is well known to enhance to a considerable extent, the value of the straw as food for animals. The experiments show about the same per cent. increase in this as in the grain. The philosophy of this is thus explained by chemistry: all plants contain the largest amount of matter soluble in water, at the period of flowering, and that the sugar and gluten of the stalk constitute its chief value as food for animals. They rapidly diminish as the seed forms, changing into insoluble woody fiber, and hay which should resemble grass in its most perfect state, is worth much less if not made until after that period. The value of wheat straw depends upon the observance of the same law, and thus it is seen that the time of harvesting, which best secures the value of both grain and straw very nearly coincides.

A saving of grain is made by early harvesting, from the fact that waste from shelling is avoided. This loss is often large in fully ripe wheat, and it is a loss no caution can avert with ripe grain. The loss from rust, also, will in most cases be thus prevented. This disease generally makes its appearance at about that stage of growth recommended for cutting the grain, and whenever it does appear, its injuries can at once be checked by harvesting.

Early harvesting allows more time for the work, so that the business of securing the crop is not crowded into a few days, in which it must be accomplished, or serious loss result from over-ripening and shelling, and if the weather is bad, from growing in the ear.

The proper maturity for cutting may be judged of more accurately, perhaps, if described as that when the stalk immediately below the head, for two or three inches, becomes yellow and dry, consequently cutting off the circulation—and the grain, though soft and doughy, ceases to yield any milk upon pressure. This occurs about a fortnight before the seed becomes dead ripe, as before remarked.

Digitized by Google

In early harvesting, of course, greater attention must be given to the curing of the crop. It is advisable to allow it to lie for half a day or so in the swath before binding, and then small bundles should be made. It should be shocked up before dew falls, and will need to remain in the field for a longer time than if cut when fully ripe. Should no rain occur (which can hardly be expected), the common practice of setting up the sheaves in a double row, with the heads resting against each other, is simple and sufficient. Against heavy showers, however, this gives but little protection, nor is covering shocks formed in the same manner, with two sheaves laid on horizontally, the heads touching each other, a much better plan. The safest mode is to set up half a dozen sheaves in a round compact form, and cover them with two others broken in the middle, and laid on in the form of a cross, with the ends spread out, which affords a reliable cap for the shelter of the grain beneath from the usual storms of the season.

Of harvesting implements we shall not speak. The subject will no doubt be sufficiently agitated by those interested—the makers and users of these important inventions.

For these reasons, and they seem to be well established by successful practice, it certainly stands the Western farmer in hand to consider the importance of harvesting his grain at the right time, that he may have the full benefit of his labor in the harvest field. He should not yield to the tyranny of prejudice, and persistingly tread in the same old beaten track, just because "father did so," taking no heed of the improvements and increase of knowledge which are benefiting his co-laborers in the same noble pursuit.

Digitized by Google

CHAPTER XVIII.

DESCRIPTION AND CLASSIFICATION OF VARIETIES OF WHEAT.

WHEAT, botanically *Triticum*. A large and very important genus of grasses, of the terminally spiked order. About thirty species, besides a great multitude of varieties, at present are included in this order; about as many more formerly belonged to it, but now are grouped with the new genus agropyrum; and several others which formerly were included in it, more properly belong to the genera *secale*, schlerochloa, and brachyopodium. All the present tritica are hardy exotic annuals—four of them varying in hight from 6 to 24 inches, and possessing very little interest; the remainder varying in hight from 2½ to 6 feet, and ranging in value from inferior economical plants, cultivable only in their native regions to the richest cereal grasses of all the temperate parts of the civilized world. All, or almost all the agropyra are hardy perennials, and either worthless or mischievous weeds; most have a hight of between 6 and 18 inches; four of them, including the notorious couch-grass with its several varieties, are natives of Great Britain, and from thence have been introduced into this country, and nearly all the rest were and are indigenous in continental Europe.

The distinctive characters of the genus triticum in the old or extensive sense of it, are terminally spiked inflorescence—two-valved and quite or nearly equal glumes—alternate two-rowed, many flowered spikelets, transverse or so placed that the edges of the florets are toward the rachis—and two palæ surrounding the seed, the external or lower one armed or pointed, and the internal or upper one cleft at the point. The

Digitized by Google

rachis (spine) or shaft is jointed; the spaces between the joints are called the internodii; the spikelets rising one above another on each side of the rachis, constitute the spike, or ear, or head; the glume or lowermost shield of each spikelet corresponds to the calyx of non-gramineous plants, and each of the florets to a corolla; some certain florets in each species, in general, are fertile, while others are barren; and the aggregate inflorescence of the several species differs very widely in the length and form of the rachis, the size and shape and packing of the spike, the comparative length of the glumes, and the number and fertility of the florets, and above all, in the various properties of the seeds. The distinctive characters of many of the species are sufficiently obvious and invariable to serve the purposes of the most stringent classification; but those of some others, particularly of such as are very extensively cultivated and as run much into varieties, either shade off so greatly through these varieties, or are so liable to change under the influences of climate and soil and culture as to render the drawing of any precise line of demarkation between different species in some cases exceedingly difficult, and in one or two quite impossible.

Some wheats of an apparently peculiar nature have been introduced—as the Egyptian, the Polish, the Liberian, the Zealand and the Talavera—and additions are being constantly made to the stock from various parts of the world; but although differing in the proportions, which they contain of nutritive matter, as well as in some particulars connected with their growth, they have all sprung from one origin—and being composed of similar elements are consequently applied to the same purpose. Botanists indeed class some of them as a distinct species; thus for instance the Egyptian produces several ears from the same stem, which is not the case with any other sort. But when repeatedly sown upon poor land, its supernumerary ears gradually disappear and it at length loses all appearance of variety. In like manner, other kinds of wheat grown in soils and climates more favorable to vegetation

Digitized by Google

than our own, have, when first introduced, succeeded very well and had apparently become acclimated, yet in a series of years have degenerated, while other sorts imported from a more northern climate, or taken from an inferior quality of soil, have on the contrary improved.

The same circumstance occurs to those species generally distinguished as winter and spring wheat; for although they seem from their time of growth to be of a different nature, yet one can be, at pleasure, transformed into the other by the common means of culture. Thus if winter wheat be sown in the month of February, or the beginning of March, a portion of it will ripen, though the lateral shoots will be weak and the crop will only be moderate. If, however, the seed thus produced be sown the next spring it will throw out stronger stems, will tiller with more luxuriance; and if the operation be repeated in the following year, it will then be found converted into the nature of summer wheat. If, on the contrary, spring wheat be sown in the month of October, and the next winter prove severe, the crop will perish, or can only be saved if it be completely covered by a heavy fall of snow. Should the weather continue mild, the seed will then, however, produce a tolerable crop, which will ripen earlier than autumn wheat; the seed obtained from it will in the following year take longer to ripen than that of the former season; it will also tiller better and partake so much more of the nature of the winter species, that, if sown in the month of May, it will not produce a crop. Thus, also, however early the true winter wheat may be sown in autumn, it will not produce stems in the same year; but the real spring wheat will do so if sown at any time before midsummer. Similar remarks might be made, with more or less force, respecting other supposed specific characters—either such comparatively broad ones as those which distinguish the Egyptian wheats from the common cultivated wheats, or such comparatively narrow ones as those which distinguish the winter wheats from the spring wheats. Yet the instabilities and gradations in specific char-

Digitized by Google

acter, even though they were both greater and more numerous than they are, effect mainly the niceties of classification and address themselves principally to systematic botanists; and they neither prevent mutational characters from being as true indexes of intrinsic constitution and adaptations as fixed ones, nor ought to deter agriculturists from appreciating classifications which, whether serviceable or worthless to the purposes of exact botanical science, may in some way or other be decidedly useful to the purposes of farming economy.

The deterioration of varieties, from indifferent cultures, non-adaptation to soil, liability to diseases, etc., has caused the introduction of almost innumerable varieties. The following communications are inserted here as forming a portion of the history of wheat culture in Ohio:

ZANESVILLE, June 8, 1859.

JOHN H. KLIPPART, ESQ.:

Sir:—In Muskingum county, on new land, wheats of the various kinds have always produced good crops; now, as in New York and elsewhere, the yield is diminished largely on all long cultivated land. The desideratum now is to find out what manures and course of cultivation will supply the place of virgin soil. To men of science and practical experience must we look for light on this subject. The State should go to the expense of experimenting to find the remedy, or like Genessee country, we shall cease to produce wheat in quantity or certain crop. In Maryland, when I was a boy, my father raised very large crops of wheat, forty to fifty bushels per acre, on rather thin flint-stone land. Wheat every third year was sown after clover sod, and plastered lime was not used at that day; the farm lay some sixteen mile from tide-water of the Chesapeake. In Ohio, commencing 1820 and up to 1845, my lowest average crop of wheat was twenty-five bushels, and from twenty-five to fifty bushels, owing to freshness of the land and kinds of wheat. For five years after I first introduced the white wheat from Western New York, my crop averaged thirty-five bushels to the acre. Subsequently the White Blue-Stem did equally well. I found that seed introduced from a distance proved better than it would after four or five years. I would advise you to suggest a change of seed from a distance, and rely much on clover and lime as stimulants, and top-dressing of well rotted manure and ashes to hasten the ripening and increase the yield, so as to give a fifth or

Digitized by Google

tenth to the weevil and not miss it—still have a good crop left. I have not farmed for ten years, and can not experiment—wish I could.

The best varieties of wheat are red. The old Red Chaff Beardy stands at the head decidedly, it more uniformly yields a fair crop; the berry not equaled by any other red wheat; the flower much finer. This wheat, of good quality, is not excelled by any other whatever, except where fancy pastry flour is wanted. For sweet, tough bread, absorbing the greatest quantity of water, it is ahead of white wheat; and take it all in all, the Red Chaff Beardy is the best wheat for all purposes we have in the United States. The best white wheat that we get now is from Kentucky, Tennessee and Missouri, and sells here from ten to thirty cents per bushel higher than average Ohio wheat. From these a barrel of flour can be made (is made) from four bushels, five pounds, to four bushels, ten pounds, while the yield from Ohio wheat is four bushels, twenty-five pounds, to four bushels, thirty-five pounds.

I have had forty-three and a half bushels Red Chaff Beardy to the acre in early day, say about 1822.

As you are soliciting information, I concluded to drop you a line giving my views.

Yours truly,

ISAAC DILLON.

STEUBEN, June 6th, 1859.

J. H. KLIPPART:

Dear Sir:—From 1820 to 1830 the "*Red Chaff Bearded*" was generally cultivated; it was abandoned for the "*Genesee Flint.*" The Flint was cultivated until its further cultivation was prevented by the ravages of the *Midge;* it was late in ripening, but a hardy variety, and excellent for flouring. The "*White Blue Stem*" was introduced perhaps about 1848, and was a very popular variety, but was abandoned for the same reason as the last-mentioned. The "*Saul's Wheat,*" another popular variety with farmers and millers, was abandoned for the same reason as the two last-mentioned. The "*Valley Wheat*" was introduced about 1840, but was not a favorite, as it was a dark wheat, and poor for flouring, and condemned by the millers. The "*Mediterranean*" was introduced about 1840, but pretty generally condemned; the kernel being very dark, but little better than rye; the straw weak and lodged very bad, and the yield light. A few farmers persevered in its cultivation, and it rapidly improved in roundness and plumpness of kernel, stiffness of straw, hardiness, and early ripening, and therefore escaping the ravages of the midge. It is now more cultivated than all the varieties, and is generally in favor with millers; being about five cents per bushel lower than the white varieties. The Mediterranean being the only variety that

Digitized by Google

has exhibited a marked improvement in cultivation, all other varieties having retrograded. The "*Whig or Dayton Wheat*" was introduced a few years ago, on account of its early maturity, and thus escaping the midge. It has not been received with that general favor that the Mediterranean has received. The kernel is small, shells bad, unless cut very green, and does not mature as early as the Mediterranean. The last-named, and the "*Whig*," are the only two varieties now grown to any extent in this vicinity; and the Mediterranean is fast taking precedence of all others.

I am not aware that I can give you much information on the different varieties of *Corn*. We raise the common Yellow Dent, but smaller varieties than are raised in Central or Southern Ohio. We have tried the different varieties of New York corn, but they are not received with general favor. The "King Philip" or "Brown" corn has been tried, but will not be a favorite in this climate.

Yours, respectfully,

C. B. SIMMONS.

From J. Coolidge, Painsville.

The Mediterranean Wheat is considered second-best for flour, and is now about the only winter wheat we grow; the old-fashioned red and white chaff bald winter wheat, and the red chaff bearded winter wheat, were long since driven from our fields by the introduction of the several kinds of white flint wheat, to-wit: the Blue Stem, the Saul's Wheat, both bald wheat, and the Hutchinson Wheat, a bearded wheat, which were all of a superior quality for flour; but they were more liable to the weevil and rust and a decline in quality and quantity, and are but little grown. The Italian Spring Wheat is the best we grow; it is a red chaff bearded red wheat; yields from eight to ten bushels per acre; quality good for spring wheat. The Canada Club, a red bearded wheat, the Black Sea Wheat, and the Rio Grande, all red bearded spring wheat, are not reliable, and are but little grown; in fact, we grow but little spring wheat in this county.

Yours, respectfully,

J. COOLIDGE.

Since the wheat midge commenced its depredations in 1854, all the late varieties of wheat have been abandoned, and farmers generally have settled upon two kinds, viz.: the White Blue Stem and the Mediterranean. Those who have good wheat lands, very generally prefer the White Blue Stem to the Mediterranean, as being more productive and of rather a finer quality of wheat; commanding a higher price in market. But the Mediterranean is regarded as a more certain crop on an inferior wheat

Digitized by Google

soil; and a greater breadth of land is sown with it than with Blue Stem. The White Chaff Bearded (a late variety), before the appearance of the midge, had been cultivated successfully above twenty years by some of the best farmers; but since then, has been entirely abandoned. It was subject to rust on poor wheat land. The Old Red Chaff Bearded ripened early, was very free from rust, would mature on poor soil; and, before the Hessian fly made its depredations, was very generally cultivated; but the fly was very destructive to it, and it was abandoned. It was believed by many good practical farmers to be more subject to cheat than any other variety. The common Blue Stem was cultivated for some years, on account of its having a stiff straw, and not liable to lodge; but it was believed to be very subject to smut, and is also abandoned. Several other kinds have been cultivated in the county within the last twenty-five years with good success; but as early maturity to escape the midge was the great desideratum among farmers, since its appearance they have pretty much been laid aside as not maturing sufficiently early. The frost on the night of the 4th June last, almost entirely destroyed the wheat crop in the county; so that, in endeavoring to keep off Scylla, we have struck against Charybdis. The White Blue Stem is white wheat, nearly smooth; the Mediterranean is red wheat and bearded head. Both are winter varieties. Little spring wheat is sown. On soil of equal quality, the Mediterranean ripens five or six days before the White Blue Stem. From the diary of one of our best farmers, in 1855, he commenced cutting wheat on July 16th; in 1856, on July 12th; in 1857, on July 23d; in 1858, on July 9th; in 1859, effectually killed.

The White Blue Stem is rather more subject to rust, and depredation of the wheat midge, than the Mediterranean. The Hessian fly has done but little injury for several years.

The Mediterranean has improved by culture: the berry is more plump and not quite so dark colored. The White Blue Stem holds its own, which is not easily surpassed on well-cultivated, good wheat lands. The Mediterranean has been cultivated in the south part of the county about twelve years, and perhaps some other parts longer; the White Blue Stem, about eight years.

The Mediterranean does not often exceed twenty bushels per acre. As high as forty bushels per acre have been raised of White Blue Stem; but thirty is regarded a good yield.

The two kinds above named are still cultivated, and likely to be cultivated so long as the wheat midge continues its ravages. But as the wheat is so generally killed over a great part of the State, farmers are not without some hopes that the midge will be much less destructive for years to come.

Mahoning County. GEO. POW.

Digitized by Google

From D. Gregory, Delaware Co., O.

The kinds of wheat formerly raised had local names, and the same variety in different sections was not unfrequently known by different names. There were, however, two or three kinds of winter wheat that seemed to take the preference to most others; for instance, the bearded red wheat was grown in this settlement from its earliest commencement to about ten years ago, and it was the leading variety in the early stage of our settlement. A blue chaffed bald wheat was a favorite with some producers, on account of its stiff straw, which would not fall down on new land; but it was late in ripening, and consequently liable to rust. There were some varieties of bald white wheat that made excellent flour, but were abandoned, from their great liability to smut. Perhaps the most popular bald wheat we ever had was the Blue Stem, both white and red (until the Mediterranean supplanted it for its propensity to ripen earlier than any other variety, and thereby escape the weevil). The Mediterranean is the only kind of winter wheat that is safe to sow at present, and is considerably improved in quality, and appears to be improving as it becomes more thoroughly acclimated. It is not a very productive wheat, and producers differ as to its falling-off in productiveness. The best crop I ever raised yielded twenty bushels per acre, and that was ten years ago; and I believe that my crop would have yielded fully up to that rate this year, if it had not been destroyed by frost of the 5th inst. The truth is, that so little pains is taken to prepare ground properly for wheat since it became our leading crop, that we ought to expect light yields.

The monographic writers on wheat, *e. g.*, METZGER, *Europäische Cerealen*, KÖNIG, Getreide & Futter Pflanzen von Deutschland, J. W. KRAUSE, *Getreidearter*, generally arrange the classification so as to comprise seven species of wheat. Of these seven species three only have found their way into general culture in the United States.

The Polish wheat described by these monographers, is rather a rye than a wheat. Spelts have, in rare instances, been cultivated rather as an article of curiosity than for commerce or domestic consumption. I have been unable to learn that any of the varieties of the Emmers (*T. amyleum*) have ever grown in the United States. St. Peter's corn (*T. monococcum*) is seldom grown in Europe as an article for human food.

Digitized by Google

I have given a list of the varieties of wheat grown in the State of New York. This list was compiled from Prof. Emmons' Agricultural Survey, and is introduced into this work on account of our proximity and commercial relations to that State—there being no doubt varieties cultivated there which could, with great advantage, be introduced into Ohio.

Finally, the varieties of wheat grown in Ohio were classified, or rather grouped in accordance with their most obvious distinctions, namely: color and form, *i. e.*, the RED wheats form the first group, the WHITE ones the second, and the SPRING wheats the third. The group of red and white wheats are divided into BEARDED and SMOOTH varieties.

This system of grouping, if not in accordance with systematic botany, is, to say the least, the most obvious and comprehensive, and therefore the most practical.

Color, however, is perhaps too unstable to serve as a basis of classification, because many wheats are even now changing from red to white, and in all probability the present "*amber*" colored wheats are those which in the course of the next quarter or half a century will become entirely white. There is little doubt, however, that the white wheats are legitimate descendants of the red ones; the red blue-stem being the progenitor of the white blue-stem; the bearded red Mediterranean being the parent of the bearded white Mediterranean variety, and so of others. If color is disregarded in grouping there will then be that of form only remaining; all wheats must then be found in one of two groups—bearded or beardless.

The following is an outline of the classification adopted by the continental writers of Europe on this subject.

To render the classification of wheat well understood, it should be so clear and simple, that any farmer would be enabled to state the precise variety he wishes to raise, by apply ing to the seed merchant, a branch of business which should belong to the corn trade.

Digitized by Google

True Wheats (*Frumenta*).

Seeds not attached to the chaff. Rachis not brittle.

1. Common Wheat (*T. vulgare*).

Spike four-cornered, compressed, both awned and without awns. Spikelets four-flowered, the two and three lower ones fruitiferous, three-grained, very extended, longer than broad. Paleæ ventricose, truncate at its extremity, with an acuminate tooth. External valve awned, or acuminate, with a long, awn-like tooth. Internal valve thin-skinned, inacuminate. Seeds oblong, ventricose, truncate, mealy, rarely glassy.

Under this head (T. vulgare) are classed and grouped:

a. Common white bearded wheat.
b. " " and velvet bearded wheat.
c. " red bearded wheat.
d. " " velvet bearded wheat.
e. " brown " "
f. " blue " "
g. " black " "
h. White club with white seeds.
i. " " " yellow "
k. " velvet club.
l. Yellow club wheat.
m. Red " "
n. " velvet club wheat.
o. Rough beard with white seeds.
p. " " " yellow "
q. " velvet bearded.
r. Hard and red club wheat.

2. Turgid, Cone, or English Wheat (*Triticum tergidum*).

Spike regularly 4-cornered, simple, end branched, awned. *Spikelets* white, 1-flowered, from 2 to 3-seeded, 2-awned, almost as long as broad. *Glume* ventricose, short, ending in a truncated tooth. *Keel* compressed, not very elevated. *Awns* in four regular rows, almost parallel to the spike. *Seeds* ventricose, mostly farinaceous, more rarely glassy.

Digitized by Google

a. White English (spring) wheat.
b. " Wonder " "
c. Black bearded white Wonder (spring) wheat.
d. White velvet English wheat.
e. Red English (spring) wheat.
f. " Wonder wheat (spring).
g. " velvet English (winter) wheat.
h. " " Wonder " "
i. Blue English (winter) wheat.
k. " Wonder " "

3. True Bearded Wheat (*Triticum durum*).

Spike diffuse, but often hard, compact, generally roundish, apex somewhat compressed, erect, abundantly awned. *Spikelets* from three to four seeded, 1 1-2 as long as broad, mostly expanded. *Glume* long, much bent, ending in a broad and re-curved tooth, the sides compressed, its bark elevated and mucronate. *Awns* from two to three times as long as the spike, very quarrose, stiff and rough. *Seeds* long, three-cornered, rugged, mostly bright and glassy.

The varieties have been classed as "*diffuse*" and "*compact*" spikes, in the "Europaischen Cerealen," but it is now evident that these characteristics are annually changing, and most of them are assuming the compressed form; we have therefore abandoned the distinction of diffuse and compact spikes.

a. White bearded (spring) wheat.
b. White wheat with black beards (spring).
c. " velvety beard wheat (spring).
d. " " black bearded wheat (spring).
e. Red beard wheat.
f. " velvety bearded wheat.
g. Blue beard wheat.
h. Thin rared bearded wheat.

4. Polish Wheat (*Triticum Polonicum*).

Spike soft, square awned, white. Wallachian, Astrachan, Egyptian corn, Gounner, Symaker, Siberian, Cairo, Double Wheat, *Germany*. Ble d'Egypte, Ble de Surinam, Ble de

Digitized by Google

Magador, Ble de Pologne a epi divarique, *France.* Poland Wheat, *England.* Fromento di Polonia, *Italy.* Trigo di Polonia, *Spain.*

Halm from 4 to 4½ feet in length. *Blades* ½ to ¾ inch. broad, 6 to 8 inches in length. *Rachis* long, in joints, haired on the border. *Spikelets* from 14 to 18, from 2 to 3 seeded, 2 awned, 1 to 1½ inch. in length. *Glume* 1 to 1½ inches in length, ⅓ inch broad, compressed, with from 5 to 6 elevated stripes, 2 toothed, white, smooth, keel with very fine hair. *External valve* as long as palese, awned. *Internal valve* half as long as external, mostly unequal, slightly embracing the seeds. *Awns* unequal, mostly of half the length of the spike. *Seeds* ½ inch long and longer, of equal breadth, furrowed flatly, little compressed or tapered, white, almost transparent, and glassy.

It occurs sometimes upon fields in Germany as an experiment.

Poland Wheat requires a warm climate, protected situation, loose and rich soil, and very early sowing in spring.

a. Branched Polish wheat.
b. Velvety " "
c. Half awned " "
d. Club like " "

5. Speltz (*Triticum Spelta*), Linn.

The stalk 4 feet and upward, without any pith; when ripe, the same color of that of true wheat. Leaves are a foot and upward in length; the spikes vary from 3 to 9 inches in length, and very loose, and when ripe are bluish, brownish, or blackish, but seldom a bright yellow. Spikelets or breasts are 9 to 12 on each side, and are placed at considerable distance from each other, each breast has three beards—the lower breasts have 3 grains, the upper ones two only. The rachis long and very brittle. The seeds are long, somewhat triangular, deeply furrowed, reddish, glassy, opalescent, and woolly at the upper extremity. The chaff adheres to the grain like barley.

Digitized by Google

a. Bluish awned spelt wheat.
b. Red " " "
c. White " " "
d. " glabre " "
e. Red " " "

6. EMMER, OR AMEL-CORN (*T. amyleum*) SERINGE.

Stalk or Halm 5 feet long, 5 jointed, tubular, the upper joint often 2 feet long; leaves 15 inches long, nearly an inch wide, bluish green with a red edge. Spike or head 4 inches long, 2 rowed twelve to fourteen spikelets on each side, rather compactly arranged, each having 2 seeds. The rachis is small, brownish, hirsute at the joints and very brittle. The seeds are broadly furrowed, pointed at both ends, the upper end woolly; color grayish red, very glassy. The color of the spike when ripe, is bluish black. (This species is grown extensively in the Alpine valleys for bread, food for cattle, and starch; is very hardy, vigorous and productive.)

a. Black velvet amel-corn.
b. Red " "
c. White " "
d. Red compact " "
e. White " " "
f. Red velvet " "
g. " many-eared " "
h. White short awned amel-corn.
i. " smooth many eared " "
k. " velvet " " " "

ST. PETER'S CORN (*T. Monococcum L.*).

Stalk 3 feet high, stiff, 5 jointed, sometimes pithy just below the ear. Leaves 8 inch. long, narrow, and light green. Heads about 3 inches long, bearded, very much compressed laterally. There are 15 to 20 breasts or spikelets on each side, which are very compactly arranged. Each spikelet is 3 flowered, but 2 are sterile, so that each breast produced one grain only—hence the name of "*one grained wheat.*" The

Digitized by Google

rachis is very short jointed, very smooth, white, and glistening, but is so brittle that it is almost impossible to remove all the spikelets without destroying it. The seeds are flattish, being compressed on the grooved side; the groove is very faint—both ends are pointed; the point woolly; whitish color, and glassy or flinty in appearance. The seeds remain in the chaff when thrashed the same as barley. The flour is dark, but makes a sweetish sad bread. But it is chiefly grown for malting purposes. There is one variety only.

Wheats Grown in New York.—Compiled from Prof. Emmons' Agricultural Survey.

A. Winter Wheat.

Improved White Flint Wheat.—This variety resembles very closely the White Flint. It is considered by Mr. Harmon as new, having been produced by himself, by a selection of the best seed, and liming and sowing it upon a limestone soil. It is larger than the White Flint; and yet the cuticle of the kernel is equally thin, delicate, and white. It weighs, according to the statement of Mr. Harmon, when prepared for seed, 64 lbs. to the bushel. The specimen in the Agricultural Society's collection has a specific gravity of 1.310,* and was furnished by the improver of the White Flint, and hence may be regarded as authentic. The specific gravity, however, is rather less than I should have expected from the weight per bushel. Two bushels and eighteen pounds of this wheat produced 106.8 lbs. flour and 31 lbs. of bran; loss 1-2 lb., equaling in the whole 138 lbs.

White Provence Wheat.—This is a French variety, and is

* The true weight of wheat is determined by its specific gravity. The weight of a bushel of wheat will vary with the size of the kernel, and from other circumstances; while its relative weight, or that found by comparing it with an equal bulk of water, at a given temperature, depends upon its composition. The heavy varieties, or those with a high specific gravity, contain more gluten than the light: the latter contain the most starch.

Digitized by Google

regarded as one of the finest kinds of wheat. It is without beards, and has a large white kernel with a thin skin. It grows rapidly, has larger blades, and sends out a greater number of straws from a root than most varieties. The straw, however, is weak, and does not support itself well. Specific gravity, 1.297. From its low specific gravity, I infer that it weighs less to the bushel than the White and Improved Flints.

Wheatland Red Wheat.—This is a variety which has been brought out by the skill of Mr. Harmon, from the Virginia White May kind. Its chaff is red; head bald and of a medium length. It is said to weigh 66 lbs. to the bushel. Its specific gravity is 1.321. The objection to this kind is its red berry: its recommendation is that it does not rust.

Tuscan Bald Wheat.—This kind, which was introduced from Tuscany in 1837, has been laid aside in consequence of its liability to be injured or destroyed by frost. Its flour is fine and white, and its heads well filled.

Skinner Wheat.—With awns; chaff white; straw short and stiff; weight 64 lbs. to the bushel. It is not in so much esteem as to displace other kinds.

Golden-drop Wheat.—Awnless, with a red chaff and rather thick cuticle. It is inferior to other well-known kinds in Western New York.

White Blue-straw Wheat (Blue Stem of Ohio).—This kind has been received from Maryland. It is a beautiful kind, and yields a white and fine flour. Specific gravity, 1.344; with the cuticle removed, 1.379. It is worthy of observation that the specific gravity is increased by the removal of the cuticle.

Aguira Wheat.—This kind was brought, two or three years since, from Spain, by F. Townsend, Esq., of Albany. It is a very beautiful kind, the kernel being large and white. Specific gravity, 1.394. Its weight approximates more closely to the celebrated English kinds than any of the preceding.

Verplanck Wheat.—In richness of appearance, this wheat excels most others. Its kernel is very large and white; the

Digitized by Google

head long, large, and well filled. The straw is large, and tall in proportion, being at least four and a half feet. The grain, however, is light, as will be seen from its low specific gravity, which only attains 1.261.

B. Spring Wheat.

1. *Italian Spring Wheat.*—This kind, which at first was esteemed, has so far deteriorated as to be neglected.

2. *Tea Wheat, Siberian Wheat.*—As a spring wheat, it is regarded as a very good variety; giving a white berry and fine white flour. It is not subject to rust.

3. *Black Sea Wheat.*—The advantages arising from the culture of this wheat are, that it escapes the fly, ripens early, and rarely mildews. Its disadvantage is, that it yields a dark flour of an inferior quality. Its specific gravity is 1.341. In Vermont, Massachusetts, and Maine, it is often sown, as it is less liable to a failure than the finer varieties.

5. *Black-bearded Wheat.*—Awns long and stiff; heads heavy; straw large, and berry red and large; hardy.

6. *Red-bearded Wheat.*—Awn red, and standing out from the head; kernel white; chaffed. Yields a good flour. A bushel weighs from 60 to 62 pounds. It succeeds best on stiff clay loams. It has yielded 44 bushels to the acre. Its beard is objectionable.

7. *Scotch Wheat.*—Its origin is unknown. Berry large, and resembles the Indiana; straw large.

9. *Talavera Wheat.*—Awnless; chaff white; straw long, white, and stiff; heads large, long, and well filled. Specific gravity, 1.306. It is not sufficiently hardy to stand *severe winters*. It is frequently injured by the fly.

Additional Varieties of Wheat which have been Somewhat Cultivated in this State.

1. *Velvet-chaff Bald.*—Chaff greenish brown and dotted, without beard or awns.

Digitized by Google

2. *Wheatland Yellow.*—Chaff pale yellow, with short awns; heads large and berry large.

4. *Hume's White.*—Head rather long and slender; chaff yellow.

5. *Bearded Baltic.*—Head thick and heavy; chaff yellowish brown, bearded; beards moderately long.

6. *Skinner's Club.*—Kernels clustered in whorls; chaff greenish yellow, bearded.

7. *Old Bearded Tuscany.*—Kernels clustered, and with long beards, greenish yellow; heads rather long.

9. *Baltic Downy.*—Chaff brown, quite downy; heads long, beardless.

10. *Old Black Bald.*—Kernels irregularly clustered; chaff brown, bearded.

11. *Poland White Bald.*—Berry irregularly clustered; chaff greenish yellow, awned, or with shortish beards.

12. *New Velvet-chaff.*—Kernels very thickly clustered, bearded.

13. *Black Velvet-chaff.*—Kernels closely set and thick; chaff very dark.

14. *Bald Baltic.*—Kernels thickly set in regular rows; chaff light brown; heads thick, heavy.

16. *Early Velvet-beard.*—Kernels clustered in whorls; heads long and yellow.

17. *Italian Spring Wheat.*—Kernels clustered, irregularly arranged upon the spike; chaff greenish yellow, thickly bearded.

18. *Bearded Valparaiso.*—Kernels in rows regularly arranged; heads short and thick, bearded.

19. *Washington Wheat.*—Heads very large and long; chaff brown; beards long; berry rather dark, but numerous, amounting to 70 or 80.

20. *Verplanck Wheat.*—Heads quite large and beautiful; berry of the largest size.

21. *Club Wheat, Pennsylvania Wheat.*—Heads short; kernels in regular rows, bearded.

Digitized by Google

22. *Spring Red-chaff.*—Kernels clustered; heads long; chaff reddish brown, bearded.

23. *Spring Wintington Wheat.*—Kernels thickly set, but irregular and large; chaff yellow, bearded.

Before introducing the catalogue of wheats grown in Ohio, it was deemed not improper to introduce a catalogue and description of the varieties grown in England, for the reason that many practical hints may be obtained from it, which the intelligent agriculturist can turn to advantage in this country. This catalogue and description was compiled from Morton's Encyclopedia of Agriculture.

Varieties of Wheat.

The varieties of wheat are much more numerous than of any other description of grain; the result, no doubt, of the greater range of climates in which it has been cultivated. From a consideration of the ordinary modes in which nature operates, both in the animal and vegetable kingdoms, the strong probability is, that all varieties of wheat have sprung from one parent stock, and that the differences now observable are the effects produced by climate, soil, and cultivation; for the differences which exist among varieties of the human race itself, are even greater than those which prevail among well-defined classes of wheat.

Thus, all varieties of wheat may be ranged under one generic head—Triticum. As this article is intended to be solely of a practical nature, we shall confine our remarks to those varieties of wheat which Mr. Lawson properly includes under the specific term Triticum sativum, or cultivated wheat. In this gentleman's arrangement of varieties of cultivated wheat, as given in his list of agricultural plants, they stand alphabetically thus:—

Whitish Beardless Varieties.

Brodies.
Cape.
Chevalier.
Chiddam or Cheltham.
Chinese.
Clustes, tall

Digitized by Google

Clustes, dwarf
Dantzic Le Couteur's Jersey
" common white.
Duke William.
Eclipse.
Essex.
Fenton.
Flanders.
Hopetown.
Hungarian.
Hunter's.
Indian.
Le Couteur's compact.
" " small round.
Morton's red strawed, white.
" " chaffed (new).
Mungoswell's.
Naples.

REDDISH BEARDLESS VARIETIES.

Blood red.
Bisshall compact.
Caucasian red.
Clover's red.
Common or old.
Creeping.
Dantzic.
Golden drop.
" or red Essex.
Flander's, or short eared.
Hickling's prolific.
Lammas or English.
Marianopoli.
Middlesex (new).
Pomeranian.
Piper's thickset.
Sack yellow.
Spalding's prolific new.
Velvet or woolly eared of Crete.
" " " common (old).
Waterloo.

Odessa.
Oxford prize.
Painted stalked.
Pearl, common white.
Rattling Jack (new).
Salmon.
Saumus.
Talavera (old).
Uxbridge.
Velvet or woolly eared common.
" " " Dantzic.
Vilmorius.
Whittington's.
Whitworth prolific.

To these may be added Archer's *Prolific White Irish*, and others of less importance.

WHITISH BEARDED VARIETIES.

Barbary thick-chaffed.
Cape spring.
Caucasian.
Col. Le Couteur's spring.
Common spring of France.
Light yellow spring.
Naples Winter.
Sicilian small hard spring.
Tuscany spring.
Tumoisic black-jointed.
Woolly eared.

REDDISH BEARDED VARIETIES.

Caucasian.
Chinese spring.
Fern or April spring.
Hedgehog winter.
Macaron's small hard.
Mayoke red.
Narbonne.
Tuscany.

Digitized by Google

Victoria spring.
Woolly eared winter.

TINGED VARIETIES.

Anti-fly or white cone.
Crawley red or corn rivet.
Louisiana.
Lozere smooth white.
Petumelle black.
Turkey large red.

As a full descriptive catalogue of all the varieties of wheat would extend far beyond the scope of this work, and is, besides, more curious than instructive, we confine our descriptive remarks to a few of the more esteemed varieties generally cultivated in the united kingdom at the present day:

Whitish Beardless Varieties.—Brodie's white wheat, originally propagated from a single ear picked by the late Mr. Brodie, Ormiston, in 1821. From thirty-two grains originally sown in 1821, the produce had multiplied to 156 bushels in 1826. When its cultivation had extended, it was generally found to produce tall straw, and a fine sample, and to be early. It is supposed by Mr. Lawson, that this variety, and that called Oxford Prize wheat, are so similar as to warrant their being considered the same, and he adds that this is the more likely, from its having been ascertained that Mr. Brodie was in the habit of sending seed wheat to Oxfordshire.

Chiddam Wheat is an old and highly esteemed English variety of white wheat, and is very generally cultivated in the finest wheat districts of that country. It is a free grower, tall-strawed, fine square ear, singularly free from awns, grain round, fair but starchy, and flour a little soft. It is remarkably well adapted for soft, easy soils in good condition, as it ripens early, is not liable to lodge or to become mildewed. Weight per bushel seldom under 61 lbs., even in wet years, and as high as 66 lbs., and 67 lbs. in dry summers. When cultivated in Scotland, the seed requires to be changed every two years from the south of England, otherwise deterioration rapidly ensues.

Cluster Dwarf White Wheat.—A remarkably short and firm-strawed variety, thick, dense ears, strong, bold sample, yields well, but only suitable for low-lying, rich, black, or

Digitized by Google

loamy soils. The tall "Fall Cluster" resembles the dwarf variety in the form of the ear. It has tall straws, and rather apt to lodge on rich soils.

Dantzic White, Col. Le Couteur's Jersey.—Originally obtained by Col. Le Couteur, from an ear of wheat imported from Dantzic. Tall, slender straw; ears moderately dense, drooping to one side when ripe; chaff thin, smooth and white; grains, oblong, and of a transparent light color; young plants hardy, and bloom early.

Experiments made by Col. Le Couteur with this variety, in 1836, gave 52 bushels per acre, of 63 lbs. per bushel, and 18 lbs. of flour yielded 24 lbs. of bread of superior quality.

Fenton Wheat.—In the summer of 1835, the late Mr. Hope, of Fenton Barns, East Lothian, noticed three ears of wheat growing from one root, in the center of a quarry on his farm. This quarry is composed of columnas basalt, and at the time the three ears were discovered, there was a large quantity of debris in the center, from which these had sprung.

The present Mr. George Hope was with his father when the plant of wheat was first noticed, and he remarked that it could not well have long straw growing in such a place, and very likely was only Hunter's wheat accidentally dropped there.

Under this impression he reluctantly, but by his father's desire, pulled the three ears of wheat when ripe, and dibbled out the produce year after year. When enabled to sow it in quantities, and to compare it with Hunter's wheat, it was found to be obviously distinct from it, and also from any other sort Mr. Hope was acquainted with. He describes it as remarkably short and stiff in the straw, and from its unequal length a sheaf is generally a mass of ears from the band upward. Although to appearance there is little straw, yet when weighed there is less difference betwixt it and longer-strawed varieties than might be supposed, in consequence of its extreme density; and in comparative trials with Hunter's wheat, Mr. Hope always found the new variety to yield as

Digitized by Google

much weight of straw, though greatly less in bulk. For some years, at first, the quality was inferior to Hunter's, but latterly it has become far superior to it; and frequently the best samples seen in Haddington market are of Fenton wheat. The only variety of wheat that Mr. Hope has ever had to surpass Fenton in point of yield of gain, is Spalding's red; but the money value of the farmer was at least equal to the latter.

The farm of Fenton Barns is generally of excellent quality, composed of rich, loamy clay, derived from basaltic and porphyritic trap, and being in a high state of cultivation.

The short, solid, firm straw of this new variety has given it a decided superiority over all other sorts. It is said that Fenton wheat is apt to become mildewed on low lying, soft soils; but while this is true to a certain extent, it is an objection to which the long-strawed sorts are still more open. Fenton wheat is, however, principally adapted for sowing on naturally rich or highly-farmed land, and is not profitable when grown on soils where there is any difficulty in obtaining bulk of straw. The ear of this variety is of moderate length, but very square and evenly shaped; grain round, plump, and of a pale white color. It weighs well in the bushel, and gives a great yield in proportion to the bulk of straw.

Hopetown.—This variety was propagated by Mr. T. Sheriff, late of Mungoswell's, East Lothian, from one ear found by the late Mr. Reid, of Drem, East Lothian. Its characteristics are long, stiff, bright-colored straw; more than average length of ear, which runs a little to a point; smooth chaff, free from awns; grain bright, plump, and transparent, producing a beautiful sample, weighing well in the bushel.

The crop is seldom so prolific as its appearance when growing would warrant.

It is rather tender in constitution; and being very tardy in completing the process of flowering, it is very liable to be injured, in consequence of the wheat fly having a long time to deposit its eggs while the blossom is opening its chaff valves. It is, however, a good sort to sow on hard soil in good condi-

Digitized by Google

tion, having a Southern exposure, where the free currents of air are not impeded by plantations or high hedges.

Hunter's Wheat is one of the oldest and most esteemed varieties in Scotland. It was discovered about half a century ago by the late Mr. Hunter, Tynefield, near Dunbas, East Lothian, by the road-side, on Coldingham Muir, Berwickshire. It is still largely cultivated in most of the eastern counties of Scotland, especially East Lothian, Fife and Forfas. It has stood its ground against many newer varieties, which, although more prolific on their first introduction, have been found to deteriorate so much, that their cultivation gradually lessened, and that of Hunter's wheat increased. It is remarkably well suited to medium and inferior soils, being hardy, and tillering very freely in the spring, and continuing its growth steadily till autumn. In these respects it has been observed that while many of the newer and finer sorts of wheat look better in winter and in spring, Hunter will, year after year, bear comparison with them either in the sheaf, stack, sack, flour-mill or bakers' shelf. It is a great favorite with millers and bakers; and its name to them is sufficient recommendation to purchase, even although the sample may want the fine color of the white sorts. Its physiological characteristics are medium length of straw and ear, the latter thickish in the middle, tapering to the neck, and point a little awned and slightly running to a point; grain, of a brownish color, a little elongated in shape, but of a fine, hard, close, flinty texture, and weighing well in the bushel, sometimes as high as 66 lbs., when grown on hard land. It is fully later in coming to maturity than most of the white wheats; and it should never be sown on fields surrounded by woods, as in such circumstances it usually suffers much from the attacks of fly. Neither should it be sown on rich alluvial soils in high condition, as it will grow too bulky, and go down before the grain is perfected.

It must be confessed that Hunter's wheat is neither so pure nor of so good quality as it used to be; and considering the

Digitized by Google

very long period it has continued to maintain its high character unimpaired, this adulteration and deterioration are no doubt to be attributed to the introduction of so many new sorts, and consequent neglect of the older variety. Any man would confer a great boon upon a large proportion of farmers in Scotland, who would carefully select one good ear of Hunter's wheat, grown on firm, hard land, in an early climate, and from this ear raise up a pure stock. Notwithstanding its impurity and deterioration, Hunter's wheat is still a great favorite in Scotland; and the only objection to be raised against it is, that it is now so mixed with other wheats, that go where you will for seed, it is impossible to obtain it pure.

Mungoswell's Wheat. — We are indebted to Mr. Sheriff, Mungoswell's, East Lothian, for this variety of wheat, as well as Hopetown wheat, and the Sheriff oat. The Mungoswell's wheat was at first considered to be earlier and more prolific than Hunter's, but judging from the fact that its cultivation has not extended in any notable degree, we are forced to conclude that it has not come up to the anticipation at first entertained regarding it. Pearl Wheat is one of the finest qualities of wheat in cultivation. It has been compared in appearance and habit of growth to Uxbridge wheat, Oxford Prize, and to Brodie's wheat. It has long, white, stiff straw; square, medium-sized ear, quite free from awns; grain small, round, plump and white, and placed very closely together in the ear; weighs very heavy in the bushel; produces an abundant quantity of flour, but of a softish quality. It is not very hardy, and rarely very prolific; but is early and well adapted for sowing on rich, easy soils, either in winter or spring. Frequent change of seeds from a better climate is necessary to prevent deterioration.

Red Chaffed Wheat.—This is a rather short-strawed, but prolific variety. The ears are very square, and the chaff of a reddish color; grain round, plump, affording a good sample. It is best adapted for rich, sheltered soils, in consequence of the stoutness of its straw and liability to shed its seeds in high winds.

Digitized by Google

Talavera Wheat, selected by Col. Le Couteur, Bellevue Villa, Jersey, from a field of the common Talavera, and first offered to the public in the Fall of 1838. Lawson describes it as a hardy sort; remarkably broad, upright foliage, often yellowish in the spring but recovers rapidly afterward, straw rather short and flexible, brittle when over-ripe: ears loose, long, and tapering to a point; grain large, oblong, thin-skinned, very white, fine sample. Talavera is best adapted for sowing in spring, on black land, or easy soils in good order, but is not a safe variety to sow on clay soils. When grown as a winter wheat, it is rather short-strawed; but if sown in spring the straw is sufficiently long to give a good bulk. Notwithstanding the beauty of the sample, it seldom weighs within two pounds per bushel of what its appearance would indicate. It is probably the best spring wheat in cultivation for the soils mentioned above.

Velvet, or Woolly-eared Wheat.—This sort is much cultivated in Sussex and Kent. Its characteristics are short straw; rather small, close, compact ears; chaff white and downy; grain of a semi-transparent, whitish color, but sometimes it presents a brownish appearance; flour abundant, and of very fine quality. It is not prolific when sown in light land; but on rich, loamy soils it yields remarkably well.

In a trial with this sort, grown in Fifeshire, in 1840, after potatoes, on light, dry land, the crop was small but of very fine quality. Sown the following year, after summer fallow, on thick, loamy land, the produce was very great. Its cultivation was, however, discontinued, in consequence of its woolly ears absorbing much moisture in damp or rainy weather, and being difficult to dry.

Some Scotch wheats have become greatly mixed with velvet wheat, especially Hunter's variety. This is very observable when the crop is in full ear, and when seen between the spectator and the sun. In wet weather, the wet may be squeezed out of the ear by the hand, so absorptive and retentive is it of moisture, while, at the same time, and along side of velvet

Digitized by Google

wheat, other and smoother chaffed varieties are perfectly dry internally. It is only a wheat for a dry climate.

White Irish Wheat has been long cultivated in Ireland under the name of the Old White Irish.* It was introduced into Fifeshire in 1845, and since then it has been cultivated very successfully on the light and inferior soils of the trap formation. It is solely a winter wheat; plants small and creeping in spring, and so great is its propensity to tiller, that it seldom grows much to length until the ground is pretty well covered with plants; straw very tall, and more like that of rye than wheat; ears very long, loose, pointed, and open, easily wet, but soon dry; chaff white, smooth, and slightly awned; grain large, oblong, and of a brownish dull color, but of a very hard, flinty nature, and a great favorite with bakers for mixing with whiter and softer sorts.

It is very prolific on medium, and even somewhat inferior soils, but on rich land it grows too tall, and goes down before the ear is filled. It is extremely hardy, and the growing plants soon recover their vigor after untoward weather. It is a late wheat, and only adapted for sowing in winter on early soils. After eight years experience in growing this sort, the writer is satisfied that no sort can compete in point of profit with the White Irish, when cultivated on light easy soils, or even on poor clay situated in an early climate.

Morton's Red Strawed White Wheat.—This variety was introduced by Mr. John Morton, late of Whitfield Example Farm, Gloucestershire. Mr. Morton originally got two ears of wheat from the Rev. Mr. Hearn, Hatford, Berkshire; both of which were very splendid, and contained upward of eighty grains each. The grains were dibbled separately, three inches apart, in six-inch rows. The seeds of the one ear produced a

* It is somewhat doubtful if the so-called "White Irish" be a true white wheat, for although the stem and chaff have all the characteristics of the white varieties, the grain is more akin to the red sorts. So far, however, as its value to the miller and baker is concerned, it is quite equal to the white sorts.

Digitized by Google

fine crop, and the second year there was as much as half an acre planted. The produce of the other ear was blighted and worthless. The name of Red Straw White Wheat was given to it by Mr. Morton, because the upper part of the stem assumes a purple or reddish color before the grain becomes ripe. The characteristics of this variety are: strong, tall, reedy straw, not apt to lodge; square, close ear, of more than average length, and not liable to shed its seeds in high winds; white; round, plump grain, when well grown, but open in the breast, and coarse in unfavorable seasons, or when cultivated on peaty soils. It is remarkably well adapted for all soils usually deficient in yield of straw. It naturally inclines to grow thin in the ground, and should, therefore, be sown a little thickly. When growing, this wheat is easily distinguished from other sorts by its peculiarly dark green color; and when nearly ripe, by the reddish color of the stem immediately below the ear. It is not so liable to mildew as most of the other white varieties of wheat; but owing to its great length of straw, it is not so well adapted for soft or peaty soils as the short straw kinds; not, however, so much on account of any deficiency of yield as from want of quality.

Red Beardless Winter Wheat—Common or Old Red Wheat.—This sort was at one time rather extensively cultivated in Britain, but it has now been all but superseded by newer and more prolific varieties. It is a hardy, stiff-strawed variety, and is well suited for poorish clay soils. Lamma, or Red English Wheat, is a highly-esteemed variety in England and the north of France, but almost unknown in Scotland. It has abundance of straw, long ear, free from awns, tapering slightly to both extremities, closely-set grains across, but a good deal apart vertically. It is well adapted for secondary and somewhat inferior soils. It is not so hardy as the common red wheat, and requires a climate where the winter is rather mild, such as prevails along the shores of the south and west of England.

Spalding's Prolific Red Wheat.—This variety is the best of

Digitized by Google

all the red wheats. No authentic account of its origin has yet been made public. From its name and character, there is reason to suppose that it is originally from Lincolnshire, upon the fenny lands of which immense crops of it are grown. The straw is remarkably tall, strong, and stiff, and not easily laid; ear long, square, and free from awn; grain round, plump, and of a yellowish color; yields remarkably well, and weighs well in the bushel. It is, however, a soft wheat, and can only be sparingly used as a mixture with more flinty wheats, when the flour is intended for the finer purposes of the baker. Spalding's wheat is well adapted for clay soils, and for soft damp soils situated in a wheat climate. It is a winter wheat, but has been found to answer well in the eastern coast of Scotland when sown in spring. On the clay soils of the eastern districts of Fifeshire, it has been known repeatedly to produce eight quarters per acre. Sown along with the old White Irish, on a light trap soil, the latter invariably beats Spalding by fully four bushels per acre, while both are always superior to Hunter's variety.

The most of the other varieties of red wheat, given in a previous table, have nearly gone out of cultivation. Hickling's Prolific was in great favor for two or three years; so also were the Blood Red and Golden Drop varieties; but now the cultivation of these has been all but discontinued, owing to their unsuitableness for the purposes of the miller and baker. One of the best of the red wheats, which has not attained much attention, is Clover's variety. It was selected and propagated by Mr. John Clover, Kirkling, Cambridgeshire. With a bag of this variety, Lawson gained the Highland Society's premium for the best red wheat, at Berwick-on-Tweed, in 1841.

Piper's Thickset.—On this we have been favored with the following, sent by the gentleman whose name it bears:—"I found a remarkable ear in my field some ten years ago, and I cultivated it till I got about forty acres. I then offered it to the public, more on account of its great yield than of its quality, though I still think it is better than the average of *red*

Digitized by Google

wheats. It was then, and perhaps is now, the shortest and stiffest strawed wheat in England. It is very thin skinned, the bran from it being very light. It is more *particularly adapted* for good land, and hollow bottom or meadow soils, where the crop is likely to be lodged or laid. In several instances it has grown sixty bushels per statute acre; but the farmers do not now grow it generally, as it does not grow *straw* enough to please them, and (which is certainly a fault) the ears are apt to *break* off at harvest time, if it is not cut early; though I don't know why farmers should not attend to their business as well as other people, and cut and cart it in proper time."

Reddish Bearded Varieties of Wheat.—The only one of any importance to the British farmer is *Fern* April, or Awny Wheat. Its characteristics are: tall, rye-like straw, not easily lodged; ear awned and spreading, running much to a point at the upper extremity; grain longish and of a reddish brown color, which weighs remarkably well in the bushel. It is a very early wheat, and can be sown any time in April, and will ripen sooner than any other variety of spring or winter wheat. It was sown at one time largely and with great success in Scotland; but latterly it deteriorated so much in produce, that it has fallen considerably out of cultivation. This deterioration is, however, greatly owing to the want of care in changing seed, and careful pickling with blue vitriol—April Wheat being more than ordinarily subject to bunt and black ball.

It sells at 4s. per quarter less than the white wheat; but, notwithstanding this drawback, it is well worthy of being cultivated on inferior soils in late districts, and also because it offers prolonged opportunities of being sown from the 1st of March to the 1st of May. The seed should be changed every two years at least, from a hard soil and early climate, and pickled, before sowing, with 2 lbs. of blue vitriol, dissolved in two gallons of water to each quarter of seed.

There should be mentioned under this head the Fingered Egyptian, or Mummy Wheat, which, though not grown to any

Digitized by Google

extent, owing to its inferior quality, is yet notable for its large produce, and is often cultivated on allotment grounds, and on small farms, where quantity, rather than quality, is desired. The Rev. G. Wilkins, of Wix, in Essex, informs us that he has grown, with no artificial assistance, four thousand fold from seed of this sort; that some of the ears have had eleven off-shoots, and that they have contained altogether 150 grains in one ear; he has also had sometimes 60 ears from a single seed. The only other varieties of red bearded wheat, worthy of cultivation, are the Cone, or Rivet wheats. There are three varieties, viz.: Cone-rivet, or Anti-fly wheat, common Rivet wheat of England, and Poll-rivet wheat.

They all produce tall, strong straw, long, well filled ears, awned, but the awns sometimes disappear before harvest, being easily broken off in windy weather; grain coarse, and the flour much disliked by bakers, except for dusting their boards and tins, for which purpose it is considered superior to all other sorts. Cone wheat is cultivated to a considerable extent in the strong soils of the southern and central districts of England, where the yield is so much greater than that of any other variety, as more than compensates for want of quality.

Hybrid Wheat.—One of the most successful attempts at hybridizing the wheat plant that has probably ever been made, was accomplished in 1846, by Mr. Hugh Raynbind, Laverstoke, Hampshire. In that year, Mr. Raynbind grew a few plants of Piper's Thickset (a red variety), in a garden at Hengrave. There he inoculated with pollen from Hopetown wheat. The produce was a few shriveled grains, which were planted early in autumn of the same year; and by dividing the roots, the number of plants was greatly increased. These plants produced a great variety of wheat, both red and white; some of the ears bearing a perfect resemblance to Piper's Thickset, while others partook of the character of the Hopetown in every thing except the color of the chaff; others had half the ear thin and open, and the rest closely set; thus in the same ear showing the characteristics of both parents. The

Digitized by Google

new hybrid which was selected and propagated is a red wheat, having a stiff straw, of medium length, and promises to be a valuable acquisition to the cultivators of red wheat.

The red varieties of wheat are generally hardier and more easily grown than the white sorts, and although of less value to the miller, they are fully more profitable to the grower, in consequence of the better crop which they produce. Another advantage the red wheats possess is their comparative immunity from the attacks of mildew and fly.

As a general rule it is profitable to cultivate red wheats on poorish soils, situated in early climates, in preference to the white sorts; but wherever the soil is a good clay, or firm loam in rich condition, the white kinds are to be preferred, as they are equally prolific, and command a higher price in the market. While it is not desirable to grow many sorts on the farm, still it is a safe plan to have two or three varieties, in order that success may be rendered more certain, and failure less felt; for it is a well observed fact, that the prolificness of any single variety of wheat differs, year by year, according to the peculiarities of the season, during the active period of the plant's growth. Thus, in a very dry year, the long-strawed sorts are most prolific; whereas, in wet seasons, the shorter varieties excel.

Then, again, the cultivation of a limited variety of wheats on the same farm is generally rendered necessary by inequalities of soil; and every farmer should try by experiment what sorts are best adapted for his particular soil or soils, and having found these out, to adhere to them until experience has supplied him with something better. A blind preference of any particular kind of wheat, because it has been cultivated time immemorial in the district, and without an effort being made to test its worth with other sorts, is as much to be condemned as a continual shifting, year after year, from one new variety to a newer, in the vain hope of getting possession of something which will throw all its predecessors in the shade. The natural tendency is for some particular sort gradually to

Digitized by Google

establish itself in a district, and for many years to hold its ground against all compeers; but, sooner or later, it is found to degenerate and give place to a newer sort. The cause of this degeneracy should be sought for less in the seed itself than in the treatment to which it is subjected. Unless on the very finest soils, and in the best climates, no variety of wheat can be long cultivated without manifesting signs of degeneracy. This arises from the imperceptible, but certain degradation of the organs of vitality, in consequence of imperfect development, and, in very bad seasons, of functional derangement, and even specific organic disease itself. The obvious cure is a habitual system of changing seed from a more genial climate; but as this sometimes can not be done without a change of variety also, many prefer to go on trusting to their favorite sort recovering its original character, rather than run the risk of sowing another from a distance, which may not be adapted to their soil and climate.

Under these circumstances, the proper mode of procedure is, to endeavor to regenerate the variety which it is desirable to retain as being best suited to any particular farm, by sending a few bushels of it, well picked and dressed, to a better soil and climate, to be grown for one or two years, and from this to obtain a fresh stock of seed with an invigorated constitution. The west and north of England could thus be supplied from the south-eastern counties of England, and the west and north of Scotland from East Lothian, or even from some county south of the Humber. A great deal can also be done in the way of maintaining the vigor and purity of seed wheat, by selecting a large well formed ear of any sort, and subjecting it to separate propagation, and garden-like culture, until a sufficient stock for field-purposes is obtained. It is by such means that nearly all our best varieties have been propagated; and although bearing new names, they are, no doubt, nothing more than finer specimens of older sorts. The full benefit of high cultivation of the soil can not be obtained without a careful attention to the kind and quality

Digitized by Google

of the seeds sown, and even the profitless results of bad cultivation may, in a considerable degree, be modified by employing good seed, adapted to the soil, and which has been procured from a better climate. For soils of a firm texture, naturally good, and in high cultivation, the best kinds of wheat are Fenton, Morton's Red-strawed White, Red-chaffed White, Pearl, and Chiddam, among the white varieties; and Spalding's Prolific, Lammas, and Clove's Red among the red sort. For medium soils, in fair condition, the long-strawed varieties should be preferred, such as Hunter's, Hopetoun, Mungoswell's for winter, and Talavera for spring sowing. On the poorer class of soils, the best sorts are "White Irish" and common Red for winter, and Fern, or April wheat for spring sowing. For soft, growthy land, Fenton's and Piper's thick-set are probably the best adapted: and even Morton's red-strawed variety has been known to stand well on such soils, but the sample is always coarse and uneven.

Digitized by Google

CHAPTER XIX.

WHEATS IN OHIO.

Red Bearded Winter Wheat.

Blizzard is a sub-variety of the "*old red bearded*" variety; it is cultivated in Ross county.

Branta.—Introduced into Putnam county in 1857, by Geo. Skinner, Esq. The straw is stiff and strong—heads long; berry red, long and hard. It ripens early, and on a black muck (poor soil for wheat) it yielded eighteen bushels for one sowed.

California.—(See plate). This variety was introduced by J. Buffington into Lawrence county ten years ago. It is hardy, and ripens before the Mediterranean, consequently it escapes all injuries from the fly, rust or midge. The yield is considerably more than that of the Mediterranean; and is regarded in Lawrence county as a prime red wheat.

China Velvet is a velvety bearded variety of red wheat. It has been cultivated some eight years in Washington county, where it is seldom attacked by either rust or fly, and produces from fifteen to thirty bushels per acre. It ripens at the same time that the Mediterranean does in that county, namely, the first of July.

China was introduced into Clark county by Jeremiah Lazell, sen.; it yields from fifteen to thirty-six bushels per acre, according to soil, cultivation and season, and ripens at the same time that the Mediterranean does, namely, about the first of July.

Club.—Was introduced into Stark county three years ago

Digitized by Google

by Hon. Thos. W. Chapman, of Navarre. It yields from fifteen to twenty-five bushels per acre, is subject to "rust, fly and weevil" (midge), chiefly on account of its late ripening, namely, about eight or ten days later than the Mediterranean. Undoubtedly a southern wheat.

Crate Whits.—In Huron, and some other northern county, a variety called the crate was considerably cultivated during a period of some twenty-five years, but finally abandoned on account of the ravages of the midge. It ripened about the tenth of July, yielded about twenty bushels per acre under ordinary cultivation, and yielded forty pounds of good flour per bushel. It is nowhere cultivated in the State at present.

Cretan Wheat. — (Binkelweizen, German). I am indebted to Geo. Skinner, Esq., of Kalida, for some excellent specimens of this variety of wheat. He sent it under the name of "*Long Red wheat.*" The straw is light; it ripens early, and yields at the rate of sixteen bushels for one of seed. The berry is red, long, shrunken and flinty. It has from ten to twelve breasts on each side, and generally has three grains in each breast. It required a dry, cool season to bring it into perfection. It may prove a valuable acquisition when it is perfectly acclimated, but at present its grains do not present a very marketable appearance.

CRETAN WHEAT.

Canada Flint was introduced into Licking county in 1844, by Thos. Wilson. It ripened about the 10th of July; it produced good flour, but for some reason was soon abandoned.

Digitized by Google

There is a *white* bearded wheat bearing the same name which is yet cultivated.

Egyptian Wheat. — Has been highly commended in the news journals, and is known under the names of Egyptian, Syrian, Smyrna, Many Spiked, Reed, and Wild-goose wheat. It derives its latter name from a story, which is current in the north, that four or five kernels, from which the American stock has proceeded, were found in the crop of a wild goose, which was shot on the west shore of Lake Champlain. It is called *reed* wheat from the great strength of its straw, which serves to prevent its being prostrated in the field. It does not yield so much flour or meal as other kinds of wheat; and the flour is scarcely superior to that obtained from the finest barley. We find it described in some authorities as Mummy Wheat, or Wheat Three Thousand Years Old. The following is a brief popular alleged history of it: It is said that some years ago a gentleman having occasion to unroll an Egyptian mummy, found inclosed with the body a few grains of wheat, which afterward, upon being sown with the modern Egyptian wheat, was found to be entirely dissimilar. The former contained nearly a hundred stalks, ranging in length from nearly five to upward of six feet, the leaves broader than usual, and fully an average as to length. The grain was in two rows or triplets, and on some, twenty triplets on a side, or forty on the ear. The ear contained a few barbs or awns on the upper end, and was open and distant between the grains. It flowered nearly a fortnight before any of the varieties sown at the same period. The modern Egyptian is dwarf, not more than four feet high, closely set and barbed in every part of the ear, and its general resemblance to its ancient progenitor is not greater than that of barley to wheat. Egyptian wheat, found in the tombs of the 18th Dynasty—i. e., from B. C. 1822 to B. C. 1476—has germinated when sown in Germany, and is frequently found in the tombs of Egypt. It has been grown by P. Poorman, in Stark county.

Digitized by Google

This is an indifferent variety of wheat. The straw grows to the hight of about five feet, is thick and pithy; the leaves are often ten inches long; the head, or rather panicle, is about four inches long, and nearly two wide and deep, and when ripe is of a reddish brown. The head consists of from five to twelve small heads densely compacted; the awns or beards are often four inches long, and of a very dark brown or blackish color. The lower part of the grain is inordinately swollen—it is very starchy, but not hard or flinty.

Golden Chaff.—This very popular variety was introduced into Fairfield county some ten years ago. Six Stager introduced it into Mercer county three years ago. It yields from twenty to forty bushels per acre; it improves by high culture, is not subject to rust or fly, and ripens with the Mediterranean, about the first of July. It should be cut before fully ripe, as it sheds very readily. The berry is rather lightish red. The general appearance of the head is much like the Mediterranean, but the color of the head and straw is yellower than that of the Mediterranean. This year (1859) many of the breasts or spikelets contained four grains each. It also strongly resembles the Quaker wheat.

Genessee Flint.—Was introduced into Morgan county from Belmont county. It has been cultivated in Morgan during the past ten years; it ripens about the 25th of June, is not affected by rust; improves by culture, produces from twenty-five to forty bushels per acre, and yields forty pounds of good flour to the bushel. It is cultivated to a considerable extent, but is objectionable on account of its rough, bristling beards. There is a smooth white wheat also known by this name.

Hard Wheat.—Introduced into Putnam county by George Skinner, in 1857. The straw is light; head about three inches long, very loose, having from six to nine breasts on a side, and tapering from the base to the point. Each breast, until nearly to the top of the head, contains three grains, the remainder two only, terminating in a point with one grain.

Digitized by Google

The berry is red and shrunken. The yield is thirteen bushels for one sown. Mr. S. says it is inferior in every respect to the Mediterranean, which it closely resembles in general appearance, when in the field.

Indiana.—This variety has been cultivated during the past twelve years, in Lawrence county. It ripens about the 20th of June, consequently escapes the rust and midge; yields from fifteen to twenty bushels per acre, and produces forty pounds of good flour per bushel. There is a white, smooth wheat of the same name.

Mediterranean (see Plate).—This variety is now, perhaps, more extensively cultivated than any other variety ever has been in this State. Its general history we stated on a previous page. It was introduced into Ohio as much as thirty years ago,* but was not extensively cultivated, nor held in great esteem, because it was liable to fall or lodge, as it yet does in Erie and Mahoning counties; but continued cultivation has given it a stiff straw in most of the other counties. The berry, which at first was long and dark-red colored, has become plumper, and of a lighter color. Millers everywhere attest, with great unanimity, to its improved flouring qualities. There is little doubt, but no direct proof, that by cultivation this variety has deteriorated into the white bearded variety of Mediterranean, which is now grown in Darke and some other counties. Being a hardy variety, and less liable to change from climate and soil than some of the finer varieties, there is little doubt that the variety called Quaker wheat, in Preble county, owes its paternity to the red Mediterranean, cultivated and perhaps acclimated to a more southern latitude. In Warren county it is deteriorating.

A good crop.—Our respected fellow-citizen, William Carmichael, Esq., raised this year upon twenty-one acres of land,

* James Rollen introduced this variety into Mahoning county, under the name of "*Black Sea Wheat.*"

Digitized by Google

one thousand and twenty-six bushels of Mediterranean wheat, being a fraction below fifty-one and a half bushels to the acre, averaging sixty pounds to the bushel. This is a very great yield; larger, we believe, than was ever made before on this shore, and we question whether the State can beat it. This shows what *good farming* will accomplish. The land on which this wheat was raised, is not better wheat land than two-thirds of this county, but has been greatly improved by the use of marl and marsh mud.—*American Farmer* (*Baltimore*).

The desirable qualities of this variety are, 1st, it withstands the attack of the Hessian fly better than any other; 2nd, it is not liable to winter-kill; 3d, it improves by cultivation; 4th, and because it ripens early, but from no other cause, does it escape the rust and the midge. In several counties, where it was sowed late, it was found as susceptible to rust as any other variety, and its long and stiff beard did not protect it from the midge. It perhaps yields less now than it did fifteen or twenty years ago; although when properly cultivated it not unfrequently weighs sixty-five pounds to the bushel. Another desirable quality is attributed to it, viz.: that it will do well on a poorer soil than any other variety. A very careful farmer from Mahoning county, writes that he has raised twenty bushels to the acre on a soil in which the Blue-stem invariably failed. 5th, The certainty of the crop, rather than on account of any of its qualities, is perhaps the only reason why it has not only been continued in cultivation by the best farmers, but has become the most popular wheat in the State. Its period of ripening varies from June 15 (statement of Hon. A. L. Perrill, Lithopolis), in Fairfield county, to July 15 (statement of George Pow, New Albany), in Mahoning county; but a majority of the correspondents name July 1st, as the general period of ripening.

Missouri.—Is a velvet bearded variety, and was introduced into Lawrence county a few years since by S. Record. It has yielded thirty bushels to the acre, but does not improve with

Digitized by Google

culture; being very late, it is subject to all the diseases to which wheat is liable.

Mt. Olympus.—Was introduced into Madison county from Patent Office. The yield was good; straw and head very heavy and dark; four rowed, with heavy beards resembling barley; it was considerably affected by the midge.

Red Chaff Mediterranean, is perhaps an improved or sub-variety of the Red Bearded Mediterranean, introduced two years ago from Lancaster county, Pa., into Montgomery county, O., by S. Rohrer, who claims that it is superior in every respect to the old variety, but Mr. David French, of Miami county, thinks it inferior. It has also been cultivated during the past several years, by Wm. Benjamin Conard, of Highland Co., who claims that it is better than the old Mediterranean, says it "*stands up*" better—ripens earlier—and is not affected by the midge.

Its appearance in the field is very like the old Mediterranean; but when ripe the straw and head are considerably darker. The head tapers to a point. It has seven to nine breasts on a side, with two grains to a breast. Grain somewhat flinty. Sheds very readily; berry full and plump and rather light colored. It strongly resembles in color and appearance the Old Red Chaff bearded.

Old Red Chaff (see Plate.)—This was once a very popular variety, but is now sadly on the decline. It has been cultivated in Clermont county, for upward of 50 years. Its yield is fully equal to the Mediterranean, producing a much finer berry with a lighter colored and thinner skin. Of late years it appears much more liable to rust than formerly, while it suffers severely from the midge. Farmers would now sow more largely of this variety, were it not so difficult to procure clean seed. It ripens about the same time with the Mediterranean. Red Chaff Beardy wheat was introduced into Muskingum county, by John Dent, in 1808. But the millers set their face against it; called it a coarse, rye-like wheat; would

Digitized by Google

not make good flour, and gave several cents less per bushel for it. But it has some hardy and productive qualities which induced the farmers to persevere in cultivating it, and it ultimately so improved in character that Mr. William Galigher, an intelligent miller of Zanesville, remarked in reference to it, some seven years since, that he considered it *the* wheat of this valley, and he would not care if there was not a bushel of any other kind raised. That it was more nutritious, etc. By reference to the Patent Office Report for 1848, page 263, you will see it stated that a specimen of flour manufactured by Beaumont & Co., analyzed by the Government chemist, of Zanesville, produced a higher percentage of gluten, or nutritious matter than any specimen examined by him in any of the Eastern or Western States. There is little doubt that this flour was manufactured of Red Chaff, as it was then the principal wheat raised in the vicinity. The Mediterranean, when first introduced, was subject to precisely the same objection as the Red Chaff, but it is very rapidly improving.

The Red Chaff Beardy was introduced into Eastern Ohio, in 1808, by whom is unknown. At that early period and for many years afterward, up to 1835, it was more successfully raised than the old varieties, of White Chaff Smooth, or White Chaff Beardy; as these old varieties were subject to scab, and that it produced sick wheat so much dreaded by the first settlers of Ohio. But so soon as the Red Chaff was introduced on river and creek bottoms, it was found that it was not subject to scab, or to produce sick wheat, and hence became the prevailing variety for many years.

The Red Chaff Beardy for a number of years after it was introduced ground harsh, and did not make flour of so fair a quality as it did afterward, when it became properly acclimated, and was produced on a black oak and white oak soil, and was harvested early, while there yet remained some little greenness in the straw. Not so the Red Chaff Smooth; as a red wheat, it was soft and tender to grind into flour, and flour of an excellent quality.

Digitized by Google

Pyramidal Wheat—Hedgehog Wheat.

Pyramidal Wheat (?) Several samples of the wheat was sent to me by Geo. Skinner, Esq., of Kalida, Putnam co., O. The straw is light, and pithy toward the head—in some parts of Germany it is used for braiding or plaiting. The beards are short, very compact, and flattened laterally, so as to expose the rachis on the one side. The berry is a lightish color, rather short, plump and very hard. There are two grains only in each breast or spikelet—never three. It ripens early and yields at the rate of sixteen bushels for one of seed. It will grow on very poor soil. It is grown in many parts of Germany in preference to some better varieties, because its long beards protect it from various depredators.

Quaker Wheat.—This variety, which undoubtedly is a sub-variety of

Digitized by Google

the red bearded Mediterranean, was introduced into Preble county, about thirteen years ago by D. Dailey and Geo. D. Hendricks, who, in 1854, gave the following account of it:—"In the winter of 1844–5, I visited North Carolina on financial business for my neighbor and friend, Enoch Taylor—our worthy President; and either promiscuously or providentially (I think by Divine Providence), our brother farmer, David Dailey, of Jackson Tp., saw fit to accompany me, journeying from three to five hundred miles out of his way for company's sake. While attending church at a lonely schoolhouse in a dense pine forest, in the vicinity of the 'Shallow Ford' of 'Deep River,' and not far from the far-famed 'Beard's Hatter Shop,' brother Dailey heard of a new variety of wheat, called there and here the 'Quaker Wheat.' He having some *distant* relations or *near* acquaintances thereabouts, accompanied one of the brothers home and possessed himself of one quart, all told, of the new variety of wheat. This he placed in the end of his wallet to balance our dinner, and brought it safely to his homestead, where he now lives; and continued to sow, and sow, and re-sow the product, which has proven a greater blessing to the people of Preble county than any other one incident in her history; and why? is asked mentally by scores of farmers here who are not advised of its properties and qualities. It is the very kind of wheat desired by all; a large berry, thin bran; and it has almost proved impervious to all the evils attending the raising of wheat in this latitude. It, like the Mediterranean, is not so liable to destruction by rust or devastation by the fly—stands winter freezing better than most varieties; and, take it all in all, it is the best, because the surest variety raised north or south of us—yielding from 45 to 50 lbs. of flour to the bushel. So far as we know, it has made at worst (the season of general rust, and this year of general winter freezing and ravages of the fly) an average crop, while, with the exceptions of these two years, it has, under good tillage, increased the average product per acre from twenty to forty per cent.

Digitized by Google

With from ordinary to first-rate tillage on good ground, its yield will range from 12 to 40 bushels per acre. And so great has it grown in favor in portions of this county, that it is all-the-go with our wheat-growers.

"Now mark what this one quart of wheat has done for this people in the short period of nine years. I think I am in bounds of reason, when I aver that this community has been directly or indirectly benefited more than $100,000; and had all the increase of seed been only applied to sowing, the advantages would have been still greater—far, far beyond the comprehension of the ordinary thinker; yes, millions of bushels beyond what even a mathematician would naturally suppose. If we estimate the first quart to produce 20 quarts, and continue that amount in arithmetical progression, we have the astounding product at the ninth (the past) harvest, of sixteen thousand million bushels—quite enough to seed all creation and bread 'the rest of mankind.'

"I have been thus explicit in giving you the pedigree of this 'Quaker Wheat,' because of its paying properties, as also to reach your ear in regard to the necessity and importance of not only the members of this association of human benefactors, but all others engaged in agriculture, to increase the productiveness of their farms. If the average yield per acre in Preble county should, as it can, increase ten per cent., it would add at least $100,000 to the wealth of the producers of old Preble."

This wheat originally had a red chaff, which by careful and thorough cultivation has been changed into a white chaff. It has become quite a popular variety in Preble and the adjacent counties. In appearance it much resembles the Mediterranean (see plate). The berry is of rather a finer quality than the Mediterranean.

This variety owes much of its popularity to the fact that it ripens at the same time that the Mediterranean does (June 25 to 28), thus securing it against the rust and midge.

Red Chaff, Baltimore Red Chaff.—This is perhaps a sport

Digitized by Google

or variety of the Old Red Chaff. Forty years ago it was introduced into Holmes county by J. Mackey. It has been cultivated for more than 30 years in some of the northern counties; it is a good wheat but has a very weak straw, and consequently liable to lodge; the yield is about the same as the Mediterranean, and as it ripens about the same time as the latter, it is no more liable to attacks of the midge, fly, or rust. It is generally being superseded by the Mediterranean, although the most of our correspondents are of the opinion that the berry improves by culture.

Rock.—Ten years ago H. Rogers introduced this variety into Hamilton county, where it is steadily gaining friends as it improves by cultivation. It possibly is a variety of the Mediterranean, as it ripens at the same time, but yields rather a larger product, and is equally exempt from all the injuries incident to this cereal.

Red Bearded.—This is a sub-variety, if not a synonym of the *Old Red Chaff*, differing from it no more than might reasonably be expected by culture, soil, etc. It is one of the varieties introduced into the State at an early day. Gen. J. T. Worthington writes that it has been cultivated upward of 40 years in Ross county. Twenty-five years ago Thomas Gardner introduced it into Lawrence county. It is a variety well known to all the "early settlers" throughout the entire State. It does not yield as well as the Mediterranean, ripens rather later, and is liable to be attacked by rust.

Stubble.—This variety once gave promise of great popularity, but being rather late, it could not so well, as some of the other varieties, withstand the attacks of insects, rust, etc., and is now, we believe, entirely abandoned.

Sidle.—This is one of those sports which so frequently occur in the culture of wheat. There is no doubt that this variety owes it paternity to the *Old Red Chaff*, and for all practical purposes may be regarded as an improvement on the old variety. It was introduced into Muskingum county about sixteen years ago, the seed having been brought from Chester

Digitized by Google

county, Pennsylvania. It has been affected very slightly by culture, soil, etc., has yielded 33 bushels to the acre, is hardy, not liable to be attacked by midge or rust. It ripens fully ten days later than the Mediterranean.

Shot.—This variety was introduced into Seneca county five years ago by Wm. Barrick; one year afterward it was introduced into Montgomery county. It produces a better yield than the Mediterranean; ripens at the same time, but in Seneca county is subject to injury from insects, which it escapes in Montgomery.

Star Buck.—This variety has been cultivated in Lawrence county during the past several years. It ripens at about the same time that the Mediterranean does; is not affected by fly or rust, and yields largely a superior quality of flour.

Turkey was introduced into Miami county three years ago from the Patent Office. It ripens about the first of July; is not affected by rust or weevil; improves by culture, and yields 45 pounds of good quality of flour per bushel. The yield per acre under ordinary cultivation is about 25 bushels. Mr. G. W. Morris, of Troy, is of opinion that this variety will prove to be a valuable acquisition.

Velvet or Crate (see Plate).—Twenty-five years ago this variety was introduced into Muskingum county, where it has yielded 35 bushels per acre. Twenty years ago it was introduced into Defiance county, but does not yield as well there. It ripens fully ten days later than the Mediterranean, and is subject to rust, but remains stationary, *i. e.*, it neither improves nor deteriorates by culture. But the flour from it is very coarse and dark. It requires a strong soil—has long awns—the chaff and bran both are of a reddish cast.

White Chaff.—This variety has been cultivated during the past 15 or 20 years in Preble county. It yields about 15 bushels per acre; degenerates by cultivation, is seriously affected by midge and rust, and ripens several days later than the Mediterranean. It is considered as being "*worn out;*" in other words, there are many varieties which yield more, and

Digitized by Google

are not so precarious, so that the variety in question has been abandoned.

Yellow Bearded.—This variety was introduced into Defiance county some 15 years ago, by Mr. Churchman. It yields about as well as the Mediterranean, ripens at the same time that the latter does (July 4), and is equally exempt from injuries by insects, rust, etc.; and, more than all, yields a greater proportion and better quality of flour.

SMOOTH RED WINTER WHEATS.

Alabama.—See May.

Australia (see Plate).—This variety was introduced into Richland county by S. H. Tranger, three or four years ago. The straw is bright yellow, the head a darkish brown of medium size; there are from 9 to 12 breasts on each side, each containing 3 grains. The breasts are rather loose at the lower part of the head, but more compact at the top. It ripens about the 10th of July; yields 20 bushels per acre under ordinary culture. The berry is large, amber colored, plump—weighs 62 pounds to the bushel, yields 42 pounds of fine, or 39 pounds of superfine flour per bushel. The chaff is heavy, and the grain is not much affected by the fly.

Blue Chaff.—This variety has been cultivated in Tuscarawas county during the past forty years, and about 15 years in Van Wert. On good high lands, with a sunny slope, it has frequently yielded 35 bushels to the acre. It improves by culture; is somewhat subject to rust, fly, and midge, but ripens nearly a week later than the Mediterranean. It yields 40 pounds of good flour per bushel.

Blue Stem.—Many of the more recent varieties of smooth red wheats were no doubt derived from this standard variety. We find it cultivated in Stark, Tuscarawas and Carroll counties, full forty years ago. It was no doubt brought there by immigrants from Pennsylvania. Twenty-five years ago Wm. Hughs sowed some in Holmes county; it has been a standard variety for the last 25 or 30 years in Harrison, Hocking, Cosh-

Digitized by Google

ocoton, Morgan and Sandusky counties, as well as in those above named. There is perhaps no variety which repays good cultivation so well, or yields so little when indifferently cultivated as does this variety. When properly managed and in a favorable season it has yielded as much as 40 bushels to the acre—(Stark, Tuscarawas, Carroll and Harrison counties), but on the other hand in quite a number of counties in ordinary seasons it yielded no more than 8 to 10 bushels. It ripens three to six days later than the Mediterranean (bearded), is slightly subject to fly, rust and midge. We have learned of a single instance only where it was winter-killed, and that was on a bleak knob in Harrison county. A very intelligent correspondent from Tuscarawas county says that "the county would be many thousand dollars richer if no other variety of red wheat had ever been introduced. It makes as good a quality of flour as does any red wheat. There is a *white* wheat known by the same name."

Carolina, Kentucky Red (see Plate).—This variety is known as *Kentucky*, or *Early-ripe*, in Darke county, where it was introduced eighteen years ago by J. Hunter and J. P. Turpen. It was introduced undoubtedly from Kentucky direct into Logan county, under the name of "*Kentucky*, or *Early-ripe*." Eight years ago it found its way into Tuscarawas county, under the name of *Carolina wheat;* six years ago John Maidlow introduced it into Putnam county; Moses Hoagland introduced it into Holmes county several years since, and, lastly, Mr. Keys introduced it into Wayne county five years ago. Our correspondents, with great unanimity state that it thrives best on good, rich fallow grounds; yields under ordinary culture about 20 bushels per acre. In all the above named counties it appears to have escaped the midge, resisted the fly, and suffered slightly from rust, but in Logan it was from its first introduction so exceedingly liable to attacks from fly, midge and rust, that in a few years it was entirely abandoned; after 15 years culture in Butler county, it deteriorated so as to become entirely worthless. Forty-three

Digitized by Google

bushels per acre have been harvested in Putnam county. It improves by culture, and ripens at the same time that the Mediterranean does.

The head is of medium length, lightish brown when fully ripe, and the glumes (chaff) is not unfrequently spotted. Each head has from 7 to 12 breasts, generally each breast contains 3 grains. The grain is light colored, slightly flinty, and somewhat shrunken. The breasts are considerably spread out, so as to give to the head a rather flattish appearance. It should be cut before fully ripe.

Dayton, Whig, Malta, Maltese, Smooth or Bald Mediterranean (see Plate).—This variety of wheat has found its way into several counties throughout the State, from the vicinity of Dayton, but is known by the above mentioned names. The specimens forwarded to me from the several counties were all of good size—the engraving was made from a medium sized head. The apex or upper portion of the head has the breasts very much crowded, so much so that the upper seven breasts occupy no more than half the space on the rachis which the 5 lower ones do. Its general appearance is very like the Smooth White Early Ripe or Rare Ripe (see plate), but it is much wider and thicker, without being any longer. It has generally a dozen breasts on each side, and (in the specimens before me) each breast contains *five* grains, thus making 120 grains to the head. From its early maturity, appearance and quality of the grain, I prefer the name of Smooth Mediterranean. It was introduced into Preble county twelve years ago by C. Wysong; four years ago a Mr. Snyder introduced it into Seneca county, and Jacob Roher two years ago into Miami county, from Lancaster, Pa. It has also been cultivated two years in Muskingum, Perry and Washington counties. The correspondents state that it improves by culture, ripens early, generally escapes fly, midge and rust. Mr. D. P. Eghert, of Warren county, has furnished the following in relation to this wheat:—"It is the most productive; is very hardy and adapted to all the different qualities of soil, stands

Digitized by Google

up well on rich soil, is less liable to rust and not often injured by the fly. The grain is a better color than that of the bearded Mediterranean and not unfrequently weighs 66 pounds per bushel. This variety of wheat was brought from Preble county some four years ago. Our informant stated that it was first procured by picking a few seeds out of the straw remaining in a crate of China ware, imported from England or some other foreign port. It is now sown by more than half of the farmers in the neighborhood of Lebanon. J. M. Sellers produced 45 bushels per acre from this variety, so also have several others. I cheerfully recommend it to farmers as the safest variety to cultivate."

Early York, is cultivated to a slight extent only in Clark county; it is subject to all the wheat diseases incident to the country; yields, under favorable circumstances, thirty-six bushels per acre—ripens about a week later than the Mediterranean.

Garden.—This variety was once cultivated to a considerable extent in Stark, Wayne, Portage, and other northern counties; but as it ripened very late, it was of course subject to attacks from the midge, and was found to deteriorate rapidly. It yielded about twenty bushels per acre, under good culture, but was unprofitable to the miller, the bran was thick and heavy, and the flour full of specks. The head is of medium size, a little flattish, dark brown when ripe, and in general appearance strongly resembles the Kentucky red. There are from eight to ten breasts on each side of the head, each breast containing three grains, terminating with a single grain on each side at the apex.

Golden Straw.—Was introduced into Tuscarawas county in 1849, by S. Kuhn, and about the same time by A Standift in Mercer county; fifteen years ago it was introduced into Lawrence county, by T. Gardner; by Peter Fleck and Hon. Thomas W. Chapman into Stark county, in 1854; ten years ago it was taken to Holmes county, by J. Watts; and some six years ago it found its way into Coshocton county. The

Digitized by Google

straw is short and stiff, and is consequently not liable to lodge; it does best on rich sandy loams; the grain is not properly a red wheat, but an amber colored one, somewhat resembling the *old-fashioned* flint wheats; in Holmes county it is rather of a yellowish cast. It ripens rather later than the Mediterranean; yields about twenty bushels per acre; does not improve under ordinary culture, and is but little subject to injury by rust or fly. It is rapidly growing into favor, and eventually may perhaps supplant the Mediterranean, although it has won no advocates in Ross county. The head and straw when ripe are of a bright yellow, and not even tinged with brown. This year (1859) has produced some samples containing seventy to seventy-five grains per head. There are ten to fourteen breasts on each side, with three grains to the breast.

Kentucky.—See Early Ripe.

Mediterranean, Maltese, Malta, Smooth or Bald Mediterranean.—See Dayton.

May, or Alabama (see Plate).—This variety was introduced into Gallia county, twenty years ago, by J. H. and A. S. Guthrie, from Virginia; into Crawford county some ten years ago, and into Champaign county two years since, from the Shaker settlement. It ripens about the same time the Mediterranean does, but is easily winter-killed, thus betraying its southern origin; yields eighteen to twenty bushels under ordinary circumstances; it comes highly recommended from Morgan county. Its general appearance is very like that of the White Blue-stem, with this difference, viz.: the head, when fully ripe, is a deeper yellow than the Blue-stem; the stem just below the head is a pale greenish-blue. There are from eight to twelve breasts on each side, with four grains in a breast. Specimens submitted to me for examination have not unfrequently produced eighty grains per head. It produces forty pounds of superfine flour per bushel. It was harvested in Lawrence county, May 26, 1859.

Rock, or Club.—Was introduced into Morgan county, by

Digitized by Google

George Newman. It ripens about the fourth of July; produced about 15 bushels per acre; but is no longer cultivated.

May Wheat, or Watkins.—Is extensively grown in the neighborhood of Richmond. It weighs heavy, sixty-four pounds to the bushels; it matures very early, is not liable to rust, and is not injured by the fly. In 1842 it was cut as early as the 26th of May. It is not remarkable for production, but a very certain crop. It is necessary to seed heavy; does not tiller well, and will not do well on poor land; it has a smooth head, and makes good flour, and is highly valuable to those parts of Maryland which suffer so much by the ravages of the fly and rust.

Mountain Sprout.—Has been cultivated during the past ten years in Perry county. The berry is light red, and ripens about ten days later than the Mediterranean. It has generally escaped the fly, rust and midge, when the Virginia Blue-stem growing on neighboring fields was almost entirely destroyed. Under favorable circumstances it has yielded forty bushels per acre.

Red Chaff.—This is one of the oldest and most substantial varieties, and is perhaps one of the earliest varieties cultivated in the West. The straw is long, and stands up well, chaff slightly brown. It makes a beautiful white flour. It ripens about a week later than the Mediterranean; yields about the same as the latter does, but is subject to blight, fly, rust, mildew, midge, and winter-kill. It has been grown in Hocking county during the past several years. Mr. Robert A. Sherrard, of Jefferson Co., says:—The Red Chaff Smooth was a variety long and successfully cultivated in Eastern Ohio. But it gradually depreciated in weight from year to year, until the farmers at length 20 years ago quit the use of it entirely, and about the same time quit the use of the Red Chaff Beardy.

Reed Straw—Has been cultivated for the past six years in Defiance county. It ripens cotemporaneously with the Mediterranean; is very little subject to disease from any cause; yields about the same as the Mediterranean—is perhaps

Digitized by Google

a sport of the red blue stem. Yields 40 pounds of flour per bushel.

Swamp Creek.—Has been cultivated four years in Preble county.

Soule's Red Chaff.—Was introduced into the northern part of the State several years since, but is now very generally superseded by the Mediterranean.

Tappahannock, is a variety of the Genessee Flint introduced into Franklin Co., in 1858, by G. S. Innis, from Virginia—it is a hardy variety and yields well.

Tennessee.—This appears to be a new variety; it appears to be hardy, not subject to attacks of insects or rust, does best on thin land, ripens as early as the Mediterranean, yields from 12 to 30 bushels. It has been cultivated some five years in Ross county, where it has made a favorable impression. It is possible that Tennessee has been substituted for Genessee, and that this variety is after all some one of the New York red varieties. This inference is based upon its early ripening.

Turkey.—Has been cultivated in Muskingum county during the past twenty years; during that period it has deteriorated very much; at one time an average yield was 30 bushels per acre, but now much less. In consequence of it ripening about ten days later than the Mediterranean, it is liable to rust and midge.

Velvet.—Has been cultivated some three years in Muskingum, and is undoubtedly a sport of some of the old standard red varieties from Maryland or Virginia. It is subject to rust from its late ripening, being fully ten days later than the Mediterranean. It yields about 35 bushels per acre under good culture, and is said to resist the midge. It has been cultivated several years in Fayette county, where it is said to have deteriorated very much.

Virginia Blue-stem.—This variety is simply the Red Blue-stem acclimated in Virginia, and then transferred to Ohio. Being taken to Virginia from Pennsylvania, and then cultivated in this State, it has by this change of locality become

Digitized by Google

a later variety,—ripening fully four days later than the Red Blue-stem, and from ten to twelve days later than the Mediterranean. It has been cultivated in Perry county during the past five or six years, where it is much subject to fly, rust and midge.

Whig.—See Dayton.

Wabash.—Was formely cultivated in Montgomery county, but was abandoned on account of its susceptibility to disease.

Watson.—Was introduced into Coshocton county about twenty years ago. If sown seasonably it will ripen about the fourth of July, but is subject to fly, rust and midge—it is a heavy wheat, yields well in flour, and is therefore much approved by millers. The red and white Watson were mixed when first introduced, and for several years were thus cultivated until some one hand-separated several sheaves, since which time the pure red has been gradually extending in cultivation and driving out the mixed and white—the latter is no longer in cultivation.

Yellow Fly Root.—This variety was introduced into Stark county fifteen years ago, by Hon. Thomas W. Chapman, of Navarre, who has assured us that it is not liable to be injured by fly, rust or midge; that under ordinary cultivation it yields twenty-five bushels per acre. It ripens rather earlier than the Mediterranean.

Yellow Lamme.—Has been grown in Hocking and Montgomery counties, but is now abandoned on account of late ripening. The berry is yellow. It is a southern variety.

Yorkshire.—Was introduced by emigrants from England some years ago, but it was soon abandoned, both on account of its inferiority, and liability to disease.

Zimmerman.—This variety has been cultivated several years in Ross, Darke, and Tuscarawas counties; it is an amber rather than purely red wheat; ripens a week later than the Mediterranean; improves by culture; yields 30 bushels per acre, and is somewhat subject to fly. It succeeds best on good corn ground. The head is short, rather square,

Digitized by Google

very compact, of a light yellow color when fully ripe. There are from eight to twelve breasts on each side of the head, each breast containing three grains. These breasts overlie each other like shingles on a roof. Several samples, the heads of which were two inches long, only contained 60 grains. The berry short, amber colored and plump; neither flinty nor soft; seldom weighs over 60 pounds to the bushel, but yields 40 pounds of good flour.

Bearded White Winter Wheats.

Canada Flint, or, as it is often called, the Cummings wheat, from the name of the gentleman who introduced it, is a valuable English variety, that is rapidly taking the place of the common Flint wheat, and produces from one fifth to one-third more per acre than the old Flint wheat in equally favorable circumstances. It is a fine grain, bearded and very hardy; is more liable to shell in harvesting than ordinary wheat, hence should be cut earlier.

Club.—Was formerly cultivated in the northern counties, and considered a good variety, but it deteriorated in quality, and was so liable to injury from fly, rust and midge, that it is now almost entirely abandoned. It ripened almost two weeks later than the Mediterranean. A Logan county correspondent says: "It came highly recommended, but left with a bad character."

Cat Mountain.—This variety was introduced in Richland county several years since, by S. H. Tranger. It ripens about the 10th of July; is very liable to be destroyed by weevil; yields under good culture from 16 to 20 bushels per acre, and a large quantity of excellent flour. It has been abandoned.

Genessee.—This name is applied to a red bearded, and a white smooth or bald variety, as well as to the white bearded. The name properly pertains, we think, to the white smooth variety. The variety under consideration was introduced into Montgomery county eight years ago, by H. Lewton. It ripens

Digitized by Google

before the Mediterranean, does not suffer from fly, rust, or midge, and is said to be very productive.

Hutcheson.—This variety was introduced into Summit county three years ago, by Wm. Hutcheson, from Union county, Pa. It ripens rather later than the Mediterranean, yields as high as 35 bushels per acre. It has not been affected by fly, rust, or midge; has a short stiff straw, and the berry much resembles that of the White Blue-stem. It is rapidly growing in favor. It yields 40 pounds of good flour per bushel.

Kentucky White Bearded, Canada Flint, Hutchinson.—This variety was introduced into Erie county last fall. It is considered as less valuable than the White Flint. The bran is thicker. It spreads but little, and therefore requires more seed. This, however, can not be regarded as an objection to the wheat. Its straw is strong; and hence, on rich, loamy lands, it will succeed better than those with a weaker straw. The straw, too, having more substance, the grain matures or fills out after it has been cut. It is early and very productive.

It has a white chaff; heads short and heavy, well filled; shells readily; berries round, short, and white; weighs 60 to 65 lbs. to the bushel; flour very good, but not equal to the White Flint. It tillers little; the straw is strong, but liable to injury from insects.

Indiana Wheat.—White chaff, bald; berry white and large; bran thin; the berry not as flinty as the White Flint, some of the best quality weighing 64 lbs. to the bushel, producing flour of superior quality and quantity; straw is larger and longer than the White Flint; shells easily, so that there is considerable loss if it remains in the field till fully ripe. Insects have attacked it more than the Flint, and it is more liable to be winter-killed.

Mediterranean.—A variety known by this name was introduced into Darke county three years ago, by Henry Snell, and into Holmes county two years since, by Joseph Beam.

Digitized by Google

The name is not happily chosen, and there is not much propriety in naming this a white Mediterranean, except it be distinctly shown that it either came from the European neighborhood from which the *red* was originally obtained, or else the red was changed into this white—an instance of which nearly occurred several years ago on the farm of Hon. A. L. Perril, of Lithopolis, Fairfield county. This new variety is said to ripen earlier than the *red*, to improve by cultivation, and to yield from 20 to 30 bushels under ordinary circumstances, and to be exempt from injuries of the fly, rust or midge.

New York.—Three years ago this variety was introduced into Montgomery county, by J. B. White. It is said to ripen *very* early, yields well, and is exempt from the usual diseases and injuries.

Olympia.—This variety was disseminated several years since throughout the country by the Patent Office department, if we are not mistaken, as having come originally from Abraham's farm in Palestine. However excellent it may be in Holy Land, it has proved worthless in Ohio; it is exceedingly long bearded, the chaff is black, resists fly and midge, escapes rust, yields under good cultivation (G. S. Innis) ten bushels per acre, deteriorates rapidly, and ripens nearly three weeks later than the Mediterranean.

Rock.—Was cultivated some time since in Union county; it had a beautiful white berry, but because it ripened late was subject both to midge and rust. But the more serious objection was, if the season was wet about the time of ripening, a great proportion of it was damaged by sprouting. The grain protruded through the glumes, and was thus exposed to the influences of the weather.

Rochester.—There is but little doubt that this variety, as well as the Genessee and Hutchinson, are the offspring of an old variety of "*Flint*," which years ago was, and perhaps is yet, cultivated in the Genessee valley, N. Y. The following description of the original "*White Flint*," is applicable

Digitized by Google

to the Genessee and the other varieties above named:—"It is of Spanish origin, color white, heads awned, medium length and well filled; straw white, clear, and strong at the root, by which it is prevented from lodging; kernels very adhesive to the stalk. It is cultivated with success on loamy soil, and is very susceptible to injury from frost or insects. The kernel is very hard, from its silicious cuticle, in consequence of which it is less injured by fall rains, and will stand in the shock a long time without sprouting." The Rochester has been cultivated during the past fifteen years in Trumbull county. It ripens cotemporaneously with the Mediterranean, and yields full as well. It is more hardy than the old *White Flint.*

Red Bearded—Red chaff; beards standing out from the head; berry white, weighing from 60 to 62 pounds the bushel; yields flour well, and of good quality; this is a hardy variety; succeeds well after corn, or on light soils; straw not large, or very stiff. This variety would be more extensively cultivated if its beards were not objectionable. The culture of this variety has been abandoned some years.

Turkish White Flint.—Two years ago D. McMillen, Jr., of Greene county, received a package of this variety from the Patent Office. It ripens as early as the Mediterranean; not affected by fly, rust, or midge; improves by culture. The beard is long and large, and the straw firm; the chaff is purplish; the grain very hard, and rather difficult to be separated from the chaff.

Velvet.—Was introduced into Butler county, two years ago, by Stephen Clawson; it ripens rather earlier than the Mediterranean, is vigorous and healthy, appears to withstand attacks from insects and the severity of the winter, escapes the rust, and yields about 20 bushels under ordinary culture.

Velvet Chaff.—Was abandoned in Franklin county ten or twelve years ago. It yielded, under good culture, 40 bushels per acre, but deteriorated; it was very liable to injury from insects, smut, and rust.

Digitized by Google

White, White Chaff, and White Bearded, appear to be synonymous. It has been cultivated during the past 30 years in Portage county, in Stark, Wayne, Columbiana, Carroll, and about 25 years ago J. Newhouse introduced it into Holmes county; in the above named counties it is known as "*White Beardy*," in Butler county, where it has been cultivated during the last 12 years, and in Darke 10 years, it is known as "*White Chaff*." It improves by cultivation, yields under ordinary circumstances about 20 bushels per acre. In the northern portion of the State it ripens later than the Mediterranean, but in the southern counties earlier. In the north it is subject to injury from the fly, but resists it in the south.

White Flint, was cultivated some years since in Geauga Co., but deteriorated in quality, diminished in quantity, and ripened the latter part of July; it is now generally abandoned.

White Flint.—This is one of the most valuable kinds in the northern States. The heads are not long but well filled, with 30 to 40 grains; the kernel is white and flinty, large, and with thin bran. They are firmly attached to the chaff, and do not shell out, except when very ripe. The heads are rather drooping, with but few awns, the straw medium length, and very white and strong. The flour is very superior; the perfect wheat weighs from 63 to 67 pounds the bushels.

White Flint, Hannon's.—A variety improved from the above, in which the berry is larger, bran very thin, and the flour equally good, if not superior; weighs 64 pounds to the bushel. This and the above are little injured by the Hessian fly, and will stand a good deal of wet weather without injury. From New York State—not much cultivated.

Smooth White Winter Wheats.

Alabama, White May (Plate I., No. 2).—This variety has a white chaff, the heads somewhat heavier than the White Flint. For the beautiful and large proportion of superfine flour to the quantity of grain, the White May is unequaled; but for late sowing on unfavorable soil, it is not as valuable as the Flint;

Digitized by Google

it will do well sown any time in October, or on very rich land in November, and answers as a spring wheat sown in February or March.

It has been cultivated in Clermont county, during the past fifteen years. As it ripens very early it is not much subject to rust or injury from the midge, but is attacked by the fly. It is said to deteriorate. It has been cultivated some three years in Franklin county, but does not appear to be received with much favor. One year ago Stephen Clawson introduced it into Butler county. It is cultivated in Warren county, where it is in great favor, said to be fly-proof, but liable to winter-kill—best adapted to light soil.

Blue Stem (Plate).—The Blue Stem was introduced into Jefferson county, in the fall of 1804. by Wm. Sharron, near Smithfield, and for the last 30 years thought to be the most profitable variety now in use in Jefferson county. This variety holds much the same relation (so far as popularity is concerned) to the white wheats, that the Mediterranean does to the red. It is more generally cultivated than any other white wheat, there being scarcely a county in which it was not introduced, under some name or other. There is no doubt that this variety is the offspring of "*Flint*" wheat, modified and improved perhaps, by climate, soil, and culture, and known throughout the State by the various names of "Flint," "New York Flint," "Genessee," "Durst," etc. The parent variety is evidently of northern origin, but that introduced into the State is from various sources, as Pennsylvania, Maryland, Virginia, Kentucky, and New York. That introduced into Washington county 14 years ago by Dr. Johnson, from the Patent Office; into Summit 10 years ago by Wm. Lemmon and Wm. L. Palmer; into Clermont county 14 years ago by Wm. Sargent; into Muskingum 8 years ago; into Monroe 10 years ago by Alex. Sinclair; into Mercer 10 years ago by R. W. Steans; into Preble 5 years ago by J. Patterson, from the north, and has never been acclimated south of the Ohio river; but that introduced into Summit by J. Philip

Digitized by Google

8 years ago; into Holmes 10 years ago by A. Bell; into Morrow 15 years ago by A. Nevis; into Ross 10 years ago by Wm. Betts, are of the eastern acclimated variety; while that in the other portions of the State may with safety be regarded as of that variety which had been acclimated in the South. These conclusions are based upon the following premises: that that in those counties first named, or of northern origin, ripens at the same time the Mediterranean does in the respective counties, and improves in quality, and but little subject to injuries by insects or rust; the second named, or of the Pennsylvania acclimatization, invariably ripens fully a week later than the Mediterranean, and improves by cultivation. That regarded as of southern acclimatization, ripened about ten days later, was very sensitive to cold, much subject to disease, and deteriorated so rapidly that, in Montgomery, Logan, Licking, Crawford, Erie, Franklin, and Hocking, and many other counties, it was entirely abandoned. The correspondents from Washington, Tuscarawas, Trumbull and Ross, and some other counties, say it is the best variety of white wheat, all things considered, that they ever have had. Fifteen counties report it as yielding, under good culture, 40 bushels per acre. Mr. R. H. Rogers, of Venice Mills, Erie county, says: "I have known a field of 40 acres produce 40 bushels per acre." Twenty counties report 30 bushels as the yield under ordinary circumstances, while twenty-five counties report 20 to 25 bushels as the average product.

The engraving is a good representation of an average-sized head. The straw is tall but stands well, and near the head when ripe, is *blue*—hence the name "*blue stem.*" The flour is of the very best quality. This variety always commands from 10 to 15 cents per bushel more than the Mediterranean. It has a white chaff; berry white; weighs sixty-four pounds to the bushel; bran thin, produces flour of a superior quality. Formerly, this was a red wheat; now it is changed to a beautiful white. There are from 10 to 15 breasts on each side of the head, and each breast contains four grains in good seasons,

Digitized by Google

generally three grains only. It is now one of the most productive varieties cultivated in Virginia.

Boone.—Was introduced into Muskingum county about ten years ago by Wm. Boone, from Pennsylvania. It yields, under good culture, 30 bushels per acre, resists the attacks of fly and midge, escapes the rust, and is improving in quality. It ripens at the same time that the Mediterranean does.

Bull.—Mr. Fowler introduced this variety into Licking county as early as 1825, whence it found its way into Muskingum county; and thirty years ago Geo. Newman introduced it into Morgan county. In these counties it ripened from the 6th to 10th of July; and, notwithstanding it had a large straw, long head, and yielded well, it was abandoned, on account of its liability to rust and the fly. It is nowhere cultivated at present.

Club (Plate).—This variety was one among the earliest cultivated in the northern portion of the State, where it was introduced thirty years ago; the farmers in Carroll, Stark, Columbiana, and Mahoning, have grown it more or less during the past twenty-five years; and emigrants from these counties have introduced it into the western and north-western counties, but it is being superseded by less precarious varieties. It yields about 18 bushels per acre, under ordinary culture, ripens from ten days to two weeks after the Mediterranean. The berry has a thin skin, makes excellent flour, but the plant is very susceptible to injury from the fly, winter-kill, and midge. A bushel yields 40 pounds of excellent flour. The engraving represents a head grown in Franklin county (June, 1858), under very favorable circumstances; this is proof (if any is required) that it possesses considerable "*constitution.*"

Canada Flint, York Flint, and White Genessee (Plate), are sub-varieties of the old white flint. Canada flint was introduced into Adams county, by J. W. Adams, four years ago; it yields, under good culture, 40 bushels per acre; is not liable to injury from fly or rust; improves by culture, and ripens a few days after the Mediterranean. It is also cultivated in Preble county.

Digitized by Google

Cuyahoga.—Introduced into Greene county by D. McMillen, Jr. It, in all probability, is a sub-variety of the Flint. It yields about 20 bushels per acre, is slightly liable to disease, improves by cultivation, weighs well, has a white chaff, and ripens at the same time that the Mediterranean does.

Calb.—In 1845 Mr. Henry Calb, of Putnam county, noticed a few heads of a distinct variety of wheat in a field of red chaff. These heads were saved and sowed separately. The wheat proved to be a very desirable variety both for quality and quantity, making the best flour in the neighborhood and yielding for a number of years 28 bushels per acre. At first it successfully resisted fly, winter-kill, midge, and rust, but now is subject to all those evils. It is also deteriorating. It ripens a week later than the Mediterranean. Yields 45 pounds of flour per bushel.

China.—Was introduced into Defiance county from the Patent Office, eight years ago; it yielded a fair quantity of good quality flour. Fly, midge, rust, climate, soil, and culture, appear to affect it less than white wheats generally—it has yielded 30 bushels per acre, and ripens a week later than the Mediterranean.

Congress or Rock (Plate), was originally a *flinty* variety, whence came the name "Rock" (if our information is reliable). Ten years ago A. S. Guthrie introduced this variety into Gallia county from Virginia. Dr. Edwards, a member of Congress from Ohio, introduced it among his constituency and and acquaintances in Ohio (whence it has been called Congress Wheat). It is grown in Lawrence county, where Thomas Gardner introduced it six years ago, and who furnished the head from which the engraving is made; in Butler county by Benjamin Symmes, five years ago; in Fairfield by M. Landis, six years ago. It improves by culture; is very little subject to disease; yields about 25 bushels per acre, and ripens cotemporaneously with the Mediterranean.

Dutch.—A variety bearing this cognomen was introduced in Licking county in 1834 by Mr. Bodle. It yields from 20 to

Digitized by Google

30 bushels per acre—ripens about the 10th of July; but it deteriorates so rapidly, that in a short time it was entirely abandoned.

Early Ripe or Rare Ripe (Plate).—This is a new variety just introduced into Stark county by Harris Raynolds, Esq., of Canton, who sent the head from which the engraving was made. Joseph Mosher of Mt. Gilead, Morrow county, has also just introduced it. From the appearance of the head one might be led to suppose that it was a hybrid produced by the Club crossed upon the Blue-stem. It has a beautifully plump, thin-skinned berry, which yields an excellent quality of flour. It ripens several days before the Mediterranean, consequently it escapes the rust, and is not affected by the midge.

The head is of medium length; the breasts at the apex, are very compact, while those at the base are very loose and straggling, so that it is somewhat club shaped. There are 8 to 12 breasts on each side, each breast containing 4 grains. Its external appearance is precisely like that of the "*Dayton*," "*Whig*," or "*Smooth Mediterranean*," with this exception, that the latter is wider and deeper in proportion to the length than this variety. The former have 5 grains in each breast, while this does not exceed four.

Flint, Old White Flint, Bull Wheat (Plate).—Appears to have had three distinct origins, so far as Ohio is concerned, viz.: in Trumbull and other north-eastern counties it was introduced from N. Y. State some fifteen years ago—there it ripens with the Mediterranean; is not much subject to disease, and is considered a good variety. In Stark, Harrison, etc., it was introduced as much as 30 years ago from Pennsylvania, and is now almost literally "*run out*." But in Franklin and other more southern counties it was introduced from Kentucky; ripened about the 25th of July, and was in consequence, soon abandoned entirely. Ten years ago Samuel Cole introduced it into Darke county, where it is doing well; at the same time it was introduced into Tuscarawas. This flint is of Spanish origin. The head is of medium length and well filled—straw

Digitized by Google

white, clear and strong at the root, by which it is prevented from lodging; spikelets very adhesive to the rachis, and kernels very adhesive to the glumes. It succeeds best on loamy soils and is rather susceptible to injury from frosts and insects. The berry is very hard from its silicious cuticle (hence its name), in consequence of which it is less injured by fall rains, and will stand in the shock a long time without sprouting.

Genessee, Genessee Flint, Genessee White Flint (Plate).—Perhaps the first of this variety introduced into Ohio was in Warren county, by Thomas Ireland, in 1842. From there it no doubt spread through the valleys of the Miami; in many of which it forms the main crop of white wheats. It is best adapted to high and gravelly lands, and rarely if ever succeeds on a bottom soil. In Franklin county it is regarded as a much surer crop than when first introduced eight years ago. It ripens about a week later than the Mediterranean and appears to be less liable to disease than white wheats generally. It is a very fine grained wheat, and yields more flour to the bushel than any other variety. It frequently has yielded 40 bushels per acre.

Mr. D. P. Egbert of Warren county, says: "Four years ago I procured several bushels of this variety from Michigan and sowed by the side of some of the same variety, which I had been cultivating for several years, and found that the Michigan had much the finest head and yielded from 3 to 5 bushels more to the acre than that which I had formerly raised. I can account for the change only by supposing that this is a more congenial climate for it than Michigan."

Mr. David Jones writes, "It yields 44 pounds of flour to the bushel, but does not contain the strength and moisture of some other varieties. It is not so good as the Mediterranean for family use; but if ground separately and then bolted with the Mediterranean, it improves the quality of both for family use." There are 10 to 12 breasts on each side of the head, each breast containing four grains.

Golden Stem or Indiana.—Was introduced from Indiana;

Digitized by Google

has a large white kernel; cuticle thin; weight per bushel sometimes 64 pounds. It ripens a few days later than the Mediterranean, but it shells out easily when ripe. It has yielded 33 bushels to the acre, but is not adapted to strong soils. It is more liable to sprout in the stack than any other kind. It was introduced into Pike township, Stark county, some six years ago. Ten years ago it was introduced into Guernsey county. Mr. C. P. B. Sarchet says: "The Golden Stem and Mediterranean are principally raised in this county, and are regarded the most certain. The Golden Stem does not grow so tall nor is the stalk as stiff as the Mediterranean —it is liable to drift and fall when raised on very rich soil. It weighs 60 pounds per bushel, and in this market commands from 5 to 10 cents more per bushel than other varieties."

Golden Chaff, is perhaps a synonym of Shot, and is probably a sub-variety of Soule's; was introduced some fifteen years ago into Ross county. It ripens about a week earlier than the Mediterranean. Gen. Worthington says it is the earliest variety of wheat grown in the county, consequently it escapes rust, midge, etc. It yields from 8 to 16 bushels, of a small round berry, per acre; it is not much cultivated.

Golden Straw, Whig, River Bottom.—Was introduced three years ago into Stark county, by J. Fleck; four years ago into Morrow county by D. C. Bingham, of Mt. Gilead. Joseph Mosher, of Mt. Gilead, says that it is an early variety, is not liable to disease; improves by cultivation, and yields from 20 to 40 bushels per acre. It is in all probability a sub-variety of the "*Flint*" family. Mr. Fleck says it is very liable to disease.

Garden.—Was very extensively grown some 12 or 15 years ago, in Stark, Columbiana, Summit, and Mahoning counties; but is being superseded by more reliable varieties. It ripened early in July, was rather liable to disease. Twenty-five bushels per acre is the highest yield of which any account has been returned to this office. It is yet cultivated in Trumbull county. There is a red wheat known by this name also.

Digitized by Google

German.—Was introduced into Hocking county some time since, but it does not come well recommended.

Gander.—Has been cultivated in Muskingum county during the past 12 years. It ripens cotemporaneously with the Mediterranean; is not affected by the fly, rust, or midge; improves by culture, and has been known to yield thirty-five bushels per acre.

Hoover.—This variety originated in Stark county, on the farm of J. B. Hoover, and is a sub-variety of the Blue-stem. It ripens a few days later than the Mediterranean. Is liable to injury from fly, but yields about 20 bushels per acre.

Indiana.—See Golden Stem.

June.—The May wheat is known by this name in Huron county.

Lambert (Plate).—In 1849, Isaac Lambert, of Harding county, found three heads of smooth wheat, uninjured by rust or midge, in a field of Old Red Chaff bearded, which was seriously injured by both the above maladies. From these three heads have sprung the famous crops of Lambert wheat in that region. It ripens earlier than the Mediterranean. The glumes appear to have a large amount of silica in their composition, which is perhaps one reason that it is regarded as proof against the midge, by which, thus far, it has not been affected. It has yielded 20 bushels per acre. The berry is small and opaquely white. Were it not for the fact that it is regarded as proof against the midge, almost every one would prefer, both for quality and yield, the White Blue-stem, to which variety it undoubtedly owes its parentage, and which it very strongly resembles in its general appearance, as well as in its anatomical details.

Michigan.—Is a sub-variety of the Genessee Flint, introduced into Franklin county some twelve years ago, but was soon abandoned. It is also abandoned in Montgomery county, where it was cultivated several years since.

Malta, or White Smooth Mediterranean.—Has been introduced into several counties in the State, as Franklin, Wash-

Digitized by Google

ington, etc., some two years since. It is not really a white wheat, but properly belongs to a class which we have not made, namely, "*amber colored wheats.*" It ripens at the same time that the *red* Mediterranean does, and like almost all white wheats, appears to be liable to disease. It yields, under ordinary circumstances, 20 bushels per acre; but is thought to be rather too thick skinned to prove profitable for flour. Mr. Arnold, of Darke county, thinks it is a better wheat, in every respect, than the red bearded Mediterranean.

May (Plate).—During the past ten years it has been cultivated in Butler, Warren, and Clinton counties. It ripens several days earlier than the Mediterranean; has a very fine grain, and has been known to yield 45 bushels per acre on first-class soil. Although it is considered fly-proof, it is very liable to injury from late frosts, and is upon the whole best adapted to light soils. Mr. Egbert states that the wheat weighs from 64 to 67 pounds.

Orange.—Introduced four years ago into Seneca county; ripens four or five days earlier than the Mediterranean, consequently escapes the effects of rust and the ravages of the midge; improves by culture, and has yielded as high as 30 bushels per acre.

Purkey.—So far as the history of this wheat is concerned, I can do no better than to give the annexed letter entire, from Mr. Freeman G. Carey, one of the Professors in Farmers' College, near Cincinnati:

"Its history is as follows: It was obtained from England about ten years since, and brought into our neighborhood by Judge Moore, of Cheviot, Hamilton county; through him disseminated through that immediate neighborhood. I obtained it of him through Mr. Wardell, of that place, who had been raising it with success upon a thin soil for several years before he introduced it to my notice. He gave it the name of the 'Purkey' wheat. On sending some of it to Mr. Brown, of the Patent Office, he gave me as the more probable name the 'White Pirk,' as he said there was no such name as 'Pur-

Digitized by Google

key' wheat, and it answered to the description of the name as above corrected.

Query.—What authorities did Mr. D. J. Browne consult? Where did he find a description of the "*Pirk*" wheat? If Mr. Browne had consulted Vale's "*Gentleman's Companion in the business and pleasures of a country life*," written about two hundred years ago in England—the copy I have was printed in 1716—he would have found the following passage: "We find many sorts of wheat mentioned in our *Rustick authors;* as, *Whole Straw wheat*, *Red Straw wheat*, *Rivet wheat*, white and red, *Pollard wheat*, white and red, great and small; *Turkey wheat*, *Purkey wheat*, *Grey wheat*, *Flaxen wheat*, I suppose the same in some places is called *Lammas wheat*, *Chiltern*, *Ograve*, etc. [This is proof *positive* that there is such a name as "*Purkey.*"—*Klippart.*]

"Its constitution is unmistakably good, growing most vigorously even upon thin soils, and withstanding the effects of cold and drouth better than any other variety wherever tried. It has been known to yield 50 bushels to the acre, and has from 50 to 80, and even over that number of grains to the head. It will yield from 5 to 10 bushels to the acre more than the Mediterranean, sowed side by side. It has

PURKEY WHEAT.

Digitized by Google

weighed 72 lbs. to the measured bushel, and never falls below standard. Its chaff is light; kernels compact on the rachis; the head short, bald; the straw white and strong, often a little purple or inclining to red a few inches below the head—quite a characteristic mark; not liable to fall, as is the Mediterranean, and is well suited to rich or lean soils. It has been known to yield 44 lbs. of flour to the standard bushel; and is a premium flour in appearance as well as in fact, having a rich cream-like color, and will ordinarily bring 50 cents per barrel more than any flour in the market.

"Another desirable quality in this latitude is that it ripens early, about the time of the Blue Stem, and a little in advance of the White Genessee of New York. We have never analyzed it in any other way than at the table, where its merits are often discussed with a good relish."

The engraving represents the natural size of a head of this variety now in the State Agricultural Rooms, Columbus, Ohio. It was obtained from Hon. Mr. SENEY, Representative in the last Legislature, from Ross county. He obtained it from a gentleman who brought it from England. It is destined to become one of the most popular white wheats in Ohio.

River Bottom.—See *Golden Straw.*

River Rhine.—Was introduced about the year 1845 into Tuscarawas county, but as it ripened late it was liable to all the ills to which wheat is subject, and the culture of it is now abandoned.

Shot (see *Golden Chaff*).—The wheat, as well as the description, is so much like the Golden Chaff, that for all practical purposes it may be regarded as a synonym only.

Soule's (see Plate).—This wheat has been cultivated during the past fifteen years, chiefly in the northern and central counties. When first introduced into Stark county, fifteen years ago, the straw was short and very stiff, but now it has a much longer straw; correspondents from Trumbull, Tuscarawas, Summit, Wayne and Holmes say it is not as reliable as the

Digitized by Google

White Blue-stem. In Ross it has been abandoned on account of its liability to rust; in Greene they complain that it has too soft a grain; but in Sandusky, Williams, and other western counties, it is very popular. In Stark it has produced better average crops than any other variety, but is now deteriorating. It ripens nearly a week later than the Mediterranean, and appears to be more able to resist fly and midge in some localities than in others. The Summit and Holmes county millers praise the excellent quality of its flour. It yields from 15 to 40 bushels of a very large sized wheat per acre. Some writers regard this variety as a hybrid between the Old Red Chaff and White Chaff, bald. Yields 42 pounds of flour per bushel.

Siberian.—Fifteen years ago, Benjamin Travis introduced this variety into Defiance Co. It did well for several years, yielded some 35 bushels per acre. It deteriorated rather rapidly; it ripens fully a week later than the Mediterranean, and is consequently liable to rust and midge.

Texian.—This variety was introduced by C. Lets, Esq., and has been cultivated some three years in Knox Co.; it yields 25 bushels per acre under ordinary circumstances; is said to be fly-proof, but yields to rust. It ripens some days after the Mediterranean.

Turkey.—Is a wheat introduced by the Patent Office, and is met with in various parts of the State. It appears to have succeeded best in Stark Co., where it has been cultivated during the past six years. It ripens rather later than the Mediterranean; is not liable to fly, winter kill, rust, or midge; so far as change in form or quality are concerned, nothing perceptible has yet taken place. It yields (in Stark) an average crop of 20 bushels of excellent wheat per acre.

Virginia.—Was introduced many years ago into Montgomery Co., but is now entirely abandoned.

Wabash.—See Golden Stem.

White Mount.—Has been cultivated during the past six years in Meigs Co. It yields an average crop of 18 bushels,

Digitized by Google

ripens later than the Mediterranean, and is liable to be attacked by rust.

White Napoleon.—Has been cultivated for some time in Darke Co., where it seems to yield a heavier crop than either the White Flint, Genessee, Blue-stem or Mediterranean. It is said to be nearly fly and rust proof, and ripens a few days after the Mediterranean.

White Provence.—Heads middling bluish; berry large and white; bran thin, and flour good; it is early, but the straw is small, long, and soft, and very liable to fall.

White May, Virginia.—It has a white chaff, bald, much resembling the White Flint in its growth and straw; the heads are more clumped; the berry stands out more, and shells easier. The berry is white, with a very hard and flinty appearance, weighing from 63 to 66 pounds to the bushel; bran of a medium thickness, producing flour of a good quality. Its early maturity makes it valuable.

White Flint (see Flint), sometimes called *Pennsylvania White.*—There is grown in many counties a wheat which is described simply as a "*white, smooth wheat.*" It has a stiff straw, stands well, escapes the fly and midge, and appears to be almost rust proof, but it is exceedingly liable to smut. Mr. Higgins introduced it into Highland Co. seven years ago, and about the same time, or a year later, we find it in Washington county. If sown early it improves; ripens rather later than the Mediterranean, and yields from 18 to 35 bushels per acre. The head is rather compact, the breasts overlap each other somewhat; there are from 10 to 12 breasts on each side of the head, of which five or six breasts on the lower part, each contain four nice, plump, thin-skinned, and rather transparent berries, while the upper breasts have three grains only.

Wild Goose has been cultivated in Union county, but has failed to be deemed worthy of cultivation; it is an exceedingly late variety, and has nothing to recommend it. It is supposed that the seeds were dropped by wild geese in their annual migration to and from the "far north."

Digitized by Google

Old Red Chaff.—This variety has been cultivated in Huron county during the past 30 years. It is an old and favorite kind, but now liable to rust and the fly. It has a red chaff, the straw is long, the berry white, large, and plump. It weighs 62 pounds to the bushel, has a thin bran, and makes superior flour.

White Soft Wheat.—This was introduced one year ago in Putnam county by Geo. Skinner. The straw is long and strong; heads long and tapering, the breasts are so loosely arranged that they do not overlap each other; there are from 6 to 10 breasts on each side, each breast (except the upper two or three) has two short, ovate, plump, white berries. The upper breasts have one berry only. It ripens at the same time the Mediterranean does, and yields at the rate of twenty-two bushels for every one sown. Mr. Skinner thinks this variety a valuable one.

Weevil Proof.—At least half a dozen different varieties of Bearded Red, Smooth Red, Bearded and Smooth White, are claimed to be weevil proof. The notorious Weevil Proof distributed by Hon. S. S. Cox, through Franklin, Licking, and Pickaway counties is a red flint wheat.

SPRING WHEATS.

To convert winter into spring wheat, nothing more is necessary than that the winter wheat should be allowed to germinate slightly in the fall or winter, but kept from vegetation by a low temperature or freezing, until it can be sown in the spring. This is usually done by soaking and sprouting the seed, and freezing it while in this state and keeping it frozen until the season for spring sowing has arrived. Only two things seem requisite, germination and freezing. It is probable, that winter wheat sown in the fall, so late as only to germinate in the earth, without coming up, would produce a grain which would be a spring wheat if sown in April instead of September. The experiment of converting winter wheat into spring wheat, has met with great success. It retains

Digitized by Google

many of its primitive winter wheat qualities, and is inferior in no respect to the best varieties of spring wheat, and produces at the rate of 28 bushels per acre.

Grain which ripens in cold weather, late in August or September, will be heavier ordinarily than that which is hastened to maturity in hot weather. By grain is meant spring wheat. From this it might be inferred that spring wheat should be sowed late, without reference to the grain worm; and yet before the appearance of that insect, it was found that early sown wheat was ordinarily the best. This may be remedied, and late sown wheat rendered a certain and uniform crop. When the wheat grows rapidly with a large straw and broad leaf of a peculiar deep green color, having the appearance of that which grows about burnt places, the straw will rust, and the grain blast. Grain sown the 1st of May or June will be more luxuriant, with a greater growth of stalks and straw than when planted early. It follows, therefore, that so long as spring wheat is obliged to be sown late to avoid the grain worm, there is more certainty of a crop to sow it on medium soil which will yield from 15 to 18 bushels per acre, than to sow it on very rich land.

The best method of improving the varieties of wheat, will be by selecting one or more heads that combine the greatest number of desirable qualities as regards the berry, flour, length and shape of ear, quality and stiffness of straw, hardihood and liability to disease, and cultivating from these alone.

The average of the wheat crop of England per acre has been estimated at 36 bushels. In the United States the average would range between 12 and 15 bushels per acre. Fields of fifty bushels per acre are as common there as 35 are here; climate may have some influence in this great productiveness, but skillful farming more. In a large part of England, the soil on farms constantly cultivated has for many years been increasing in fertility, and the idea of exhaustion of soils, under proper cultivation, is scouted as absurd.

A superior variety of spring wheat, is the *China or Black*

Digitized by Google

Tea Wheat, and by some this is called Saltarian Wheat. The origin of this beautiful wheat is this: Some twelve years since, there was found by a merchant in Petersburg, Rensselaer county, New York, 6 or 7 kernels of this kind of wheat in a chest of black tea, which was sown. It now has the preference of all the different varieties of spring wheat. The straw is very stiff and has never been known to rust. It threshes very easily. It should be cut rather early as it is liable to shell if left till fully ripe. The quality of the flour is equal to any other spring wheat. It is said to yield from 15 to 40 bushels per acre.

Hungarian Spring Wheat, from the Patent Office, is in all probability a winter wheat.

Bald Spring Wheat.—First brought from Lord Selkirk's settlements on North Red River, and introduced by James G. Soulard. This wheat when sowed on the 15th of May, came to maturity perfectly without smut or rust, producing at the rate of 30 bushels to the acre.

Tea Wheat or Siberian Bald.—As far as flouring is concerned, a correspondent says: "I can speak from experience, and say the true Tea Wheat is A. No. 1. It can't be beat by any spring wheat that I ever ground, for quality and quantity. Black Sea Wheat is the poorest flouring kind that has come under my observation; the berry is hard, and flours a little better than Canada Corn. It bears no comparison with Tea Wheat for flouring."

Black Sea Wheat.—The grain is not as light colored as other varieties, but the berry is always plump; the quality of flour is more harsh, and not as white. Its recommendation is that it invariably yields a good return, from 20 to 40 bushels to the acre, and is not subject to the rust.

Whitington Wheat.—This is a very beautiful spring wheat. The berry is large, plump, and very white, the skin apparently thin, the head seven inches long, and the straw stout and bright. The origin of this wheat was three ears selected from a field on the mountains of Switzerland. It obtained a medal

Digitized by Google

at the Liverpool Agricultural Meeting, in 1836. It is said that it grows upon poor soils, and that 12 bushels sown have produced 300.

Canada Club and Fife.—Canada Club is beardless, white chaff, fine white berry. Straw stiff, hard and wiry—more so than any other spring wheat. It has been supposed that the Canada Club and "Fife" are the same variety. A gentleman residing in Canada, where the latter was first introduced, says: "They are decidedly distinct varieties. If sown in the same field on the same day, the Club will ripen a week earlier than the Fife, and the latter will grow and mature well in low, moist, rich soils (nearly swampy), while the former, if sown in such soils, seldom or never does any good. Hence our farmers sow Fife on their lowlands, and Club on the high and dry. There is also a marked difference in the appearance of the straw while growing, the Club having the usual straw green shade, while the other has a distinct bluish bloom upon it. The kernel or berry is much the same in size and general appearance in both varieties. The main difference consists in the Fife being lighter colored. There is also a considerable difference in the appearance of the heads—the kernels on the Club are closer or more compact than in the Fife. In hight they are nearly alike—both are heavy in the bushel, frequently going up to 65 lbs. The straw in both sorts is of medium length, but that of the Fife is much the stiffest; hence, it seldom lodges, although sown on heavy, moist soil. It has never been known to rust, which is not the case with the Club. Both descriptions yield well; on suitable, well-tilled land, 30 to 35 bushels per acre are common crops, and much more frequently obtained. The general impression is, that all things being equal, the Fife yields the best. I can not say where the Club came from, but the history of the Fife is well known. The person who introduced it lives only a short distance from me. While on his way to this country a few years ago, Mr. Fife obtained about a peck of wheat from a *Russian* vessel unloading at Glasgow—hence the name '*Fife*' and *Scotch*.

Digitized by Google

From this small beginning it has spread until each year witnesses the growing of millions of bushels of it. It has been a favorite from the start, and it does not seem likely soon to lose its good character. From one and a half to two and a half bushels per acre is the quantity sown—the latter quantity when the soil is very strong, and when the seed is sown broadcast—the former when the drill is used. Before concluding, permit me to say that you may hear of a new variety of Canadian spring wheat, under the name of 'Swamp Wheat.' I do not know it for a fact, but I guess it is only some of our 'Fife' wheat taken from home and baptized afresh."

Rock.—This is of Spanish origin. It has been cultivated in this country about forty years. It is not a fine, but is a successful variety.

Red Bearded.—This succeeds on stiff, clayey soils. The beard stands out from the head; reddish chaff, white berry, and yielding good flour.

Italian Spring.—This was much prized when first introduced, some twelve or fourteen years ago, but it has rapidly run out, and is much neglected.

Talavera.—Without beard; chaff white; long, stiff straw; head large and plump. This kind is subject to the attack of the fly, and is not sufficiently hardy to stand severe winters.

Hedgerow.—This variety has been somewhat cultivated. Of its origin, or whether it is elsewhere known by other names, I am not informed. Of late years its cultivation has been entirely neglected, in consequence of its liability to rot. In the West it has not suffered to so great an extent. It is distinguished by its short heads, which are filled out in such a manner as to give them a rectangular form. It is bearded; white chaff; bright, strong straw; round plump berry.

Poland White Bearded.—A variety which some years since was in very great favor, but at present very little if any spring wheat of any variety is cultivated. If Ohio can not produce good winter wheat, it certainly is folly in any other State to attempt it.

Digitized by Google

Spring Club was introduced into northern Ohio many years ago, but made no favorable impression on agriculturists or millers.

Indian Wheat—its Value and Culture.—I notice an inquiry in the *Country Gentleman*, in regard to "Indian Wheat." This grain was introduced into this town about twenty-three years ago, from Canada, I think; since when it has been constantly cultivated by some of our farmers, and now *nearly every* farmer raises it, although a very few, after trying it a year or two, discontinued it, some because they thought it would overrun their whole farm, and some because "the women" could not use it; neither of which do I consider valid objections. It will live in the ground over winter, so that it may be sown at any time from the harvesting of one crop to the gathering of the next; but we usually sow it after all the other crops are in, and harvest it before it is so ripe as to shell off from the straw—it being necessary to cut it when the dew is on. Our farmers often keep the same piece to Indian wheat for several successive years, and it seems to do as well so. If the soil is too rich, it "runs to straw" too much. The crop is from 45 to 50 bushels to the acre, about the same as oats, although both often produce 75 to 110 bushels per acre on our soil. The average weight is about 48 lbs. per bushel, and 16 to 18 lbs. of superfine flour per bushel. The canail I consider worth more per pound than oats for stock; it is quite bitter, and seems to act as a tonic, and sharpens the appetite much. I think this grain is worth full one quarter more than oats for horses—possessing, to a good degree, the property of corn that makes *fat*, and that of oats that produces *muscle.*—*Country Gentleman.*

Digitized by Google

CHAPTER XX.

DISEASES AND ENEMIES OF WHEAT.

As we have now given somewhat in detail the history of the wheat plant, its habitat, its physiology and chemistry, and mode of culture, we will proceed to notice at greater or less length those diseases and dangers to which it is subject during its growth, or after maturity, and which serve to diminish the certainty with which the agriculturist might otherwise depend upon an abundant supply of the "staff of life" in proportion to the ground cultivated, and the quantity of seed sown. But as many of the causes acting unfavorably upon the production of the wheat crop have been mentioned with more or less perspicuity in our foregoing remarks, we need not again dwell upon these items, when especially under consideration, at so great a length as we should do if they were not already somewhat familiar to the attentive reader.

The causes affecting the wheat plant deleteriously, may be enumerated as follows:—Terrestrial, atmospheric, agricultural, and constitutional; and these several causes and the special application of the terms here used require a few words of explanation, or must, to prevent confusion, be defined as to our application of the words.

Under the term terrestrial causes, we would include all that pertains to the soil, and its aptitude or otherwise for the culture of wheat, on account of original constitution or subsequent changes, accidental or intentional. These causes have been already discussed sufficiently fully in the foregoing pages to render superfluous more than merely to mention here that they have relation to the chemistry and constitution of the

Digitized by Google

soils, making them more or less fit to afford sustenance to the wheat plant itself, or to promote the production of plants and animals inimical to it.

Atmospheric causes affecting the wheat plant consist in the general aggregation of serial phenomena called climate, and those special departures from the usual climatic course, which give to the character of an entire year the peculiarities which are referred to as the season of such or such a year, and which modify the climate to such an extent that climatic aptitude for wheat culture varies greatly in the same place in different years.

Agricultural causes include all those separate and often distinct modifying influences affecting successful agriculture which depend upon the preparation of the grounds, their protection from obviable causes of injury to the crop during the entire process of culture, and even in the storehouse and granary after the growth of the crop is completed.

Under constitutional causes are grouped together the pathological conditions of the plant itself, and the vegetable and animal parasites and enemies by which it is endangered at any period of its existence from the moment of germination until germination again, some of which are entirely obviable and most or all of which are capable of great modification in their deleterious effects by the application of skill on the part of the agriculturist.

As many of these causes already mentioned have been discussed in other portions of this report, we will here only advert to those prominently which have not been elsewhere examined.

The conditions of the earth as to constituents and preparation have been pretty fully discussed in those parts of our report devoted to the subjects of agricultural chemistry, draining, etc., and need not be repeated in this place, and all that is here necessary is, to remind the agriculturist that due regard being had to the condition of the soil chemically, and to the proper draining, plowing, and other preparatory pro-

Digitized by Google

cesses, the percentage of chances in favor of a good and certain yield are greatly increased. And we must advert again to the fact that draining is an important part of the preparatory work for a good crop, as by draining, *winter-killing* is rendered less likely to occur, and a more constant and equable supply of moisture is secured, as draining prevents excesses at some periods of the year and deficiencies at others, both of which conditions of supply are injurious to wheat.

The atmospheric causes which affect the productiveness of the wheat plant are mostly so far removed from the control of human skill that but little can be accomplished to secure the crop from injury by the operation of these causes, among which may be mentioned untimely frosts, storms of wind, hail or rain, lack of snow, sudden and violent changes of temperature in the winter, etc., all of which are entirely removed from the control of man, and their effects can only be slightly modified by having regard to the proper mode of cultivation.

Icterus or Jaundice, is the name of a condition of the wheat stalks, which occurs most commonly upon rich argillaceous, imperfectly drained lands, after the cool rains of spring. The stalks turn yellow and many of them perish in such seasons as yield a superabundance of moisture in the spring, because the roots are elongated and enfeebled in such circumstances and do not transmit a sufficiently concentrated and nourishing sap to the plant, and they die for want of a proper pabulum to sustain their growth, which has been made rapid at the expense of their vigor. Proper draining and cultivation will in a great measure obviate this malady. If the earth be too compact and tenacious on account of the superabundance of clay in its composition, repeated plowings and manurings, with such manures as render the earth porous and mellow, are of great advantage, and if carried sufficiently far will entirely prevent the disease above named.

Blight or Withering.—A dry state of the atmosphere, and a clear sky and great heat of the sun immediately following

Digitized by Google

light showers, at the period when wheat is "in the milk," *i. e.*, when the albumen and starch are still in a liquid state, or a prolonged drought at the same period, are ordinarily the causes of a condition of the grain known by the above name, which consists essentially in a too early desiccation and maturity of the grains by means of which, not having continued in a state of growth long enough to be well-filled by a deposition of the proper contents of farina, although the skin of the grain was already fully developed, it assumes a shriveled appearance, and does not yield largely of flour. Such wheat is called *blasted*, *blighted*, *withered*, or *badly nourished*. This diseased condition is almost or quite unavoidable.

Lodging.—Wheat upon rich moist soils, although growing luxuriantly, does not produce so firm and elastic stalks as upon drier or poorer soils, because of the too dilute condition of the sap, producing large but watery, or succulent stalks, leaves them more feeble. If heavy winds succeed rains, while such stalks and head are yet heavy with the retained rain drops, they bend or break near the roots, and mat together, not being strong enough to raise up again become in part over-heated, retaining their moisture and in part dried by the rays of the sun, and if the ground be not free from weeds, these overgrow them, and they are then attacked by rust almost without fail, and the crop is lost. If only bent the stalks resume their erect posture so soon as the water is shaken off and the wind ceases blowing.

Rolling light soils after sowing, to give them more consistence, and properly draining the richer, moister lands, will prevent the occurrence of lodging to a great extent.

Tornadoes, hail-storms, and very heavy rains often break down and destroy fields of wheat when approaching maturity, but for these evils there is no remedy applicable, beyond the careful and skillful culture which may favor the development of strong healthy stalks, and the selection of such varieties of wheat as produce a short, firm straw, for cultivation in those localities which are more particularly liable to the occurrence

Digitized by Google

of heavy storms. But these principles have already been sufficiently discussed in our preceding remarks, and we will pass on to a consideration of the next branch of this important subject, the diseases and accidents to which wheat is liable, to wit: agricultural causes of failure to secure a good crop.

Many of the agricultural causes of a deficient crop have already been pointed out and their remedies suggested, and but few of these remain to be mentioned. In our remarks upon the wheat region, manuring, the chemistry of agriculture, etc., we have pretty fully demonstrated that a proper selection of the seed, and preparation of the ground, together with a nice discrimination of the season of sowing, go far toward securing a profitable return for labor applied, but this is not all, for some few accidents to which wheat is liable, are so strictly agricultural that they deserve a special notice here or elsewhere in the remainder of this disquisition. The only one we will advert to here, however, is

Germination of Wheat in the Straw.—The importance of a discussion of this subject may be inferred from a statement made by reliable authority, M. Emilien Dupont, in his "Essai sur . . . le ble," to the effect that the loss of one-third of the wheat crop of Lower Canada, in 1855, was due to this cause alone.

When wheat has reached entire maturity it constantly has a natural tendency, in favorable circumstances, to undergo the process of germination, and if, at the time of harvesting, the wheat be exposed to the conjoined influences of warmth and moisture, even while yet in the straw, germination will occur, and those changes of the contents of the grain already adverted to, and which impair or destroy entirely the fitness of it for the purposes of bread-making, must necessarily occur. Agriculturists who are not careful to avoid these influences, that is, those who permit their wheat to lie a length of time on the ground, and exposed to the dews and rains of the season and the heat of the sun, will find their grain sprouted,

Digitized by Google

and even a comparatively small portion being thus affected, the quality of the grain is greatly deteriorated.

This evil, so greatly injurious to the interests of the community at large, as well as the individual producer, is one which it is comparatively easy to obviate, as will be seen by the following directions, and reasons for these directions, to prevent its occurrence.

Heat and moisture conjointly operating cause germination in grains entirely matured, and it is only required to prevent the concurrence of these causes and conditions to prevent the evil, and the means are suggested almost spontaneously to the intelligent farmer.

The time at which wheat is cut is a matter of importance for two reasons,—the first is that an earlier or later cutting has an influence upon the germinating tendency of the grain while necessarily remaining in the straw, and the second is that it also determines in a greater or less degree the falling out and loss of the grains in the various handlings to which wheat is subjected, until at last threshed out in such manner as to secure the product.

The most reliable information we have been able to obtain, leads us to adopt the opinion that grain cut a short time before complete maturity, secures a better yield than when cutting is postponed until such perfect maturity has been reached, because, first, the grain is not so liable to shed out during the process of harvesting; and because, second, the maturation of the grain goes on in the straw while this is drying, and is completed when desiccation has been completed, and it can not germinate until this maturation has been perfected, at which time, if the cutting has been early, the straw will be sufficiently dry to permit its deposit in barns or stacks with safety. The grain may be cut with advantage to the quality as well as quantity of the product, while the husk or chaff has still a number of green streaks or markings upon it, and this early cutting is a certain preventive of sprouting in the

Digitized by Google

sheaf for some days at least after cutting, and should, for the purpose of gaining time, and saving grain and making it of better quality even, always be performed.

After cutting, an immediate shocking up of the grain in such a manner as to favor desiccation and prevent the influence of moist heat, should be practiced; and if properly performed, shocking will secure the grain against this evil for an indefinite period of time. The most economical modes of making shocks are, perhaps, the following:

Conical shocks are made by placing one sheaf upright, arranging four others around this in a slanting position, and then filling the intervals between these with four others, and then capping the whole by a large sheaf bound near the butt of the straw and spread equally over all. The nine shock sheaves should not exceed one foot in diameter each.

Diamond Shocks.—Take ten sheaves and place them in two parallel lines, join their heads, and give them a slant. Then join two other sheaves by a good band, and place them on the others in such a manner that they may incline the heads toward the ground and spread over all the others. The shocks of this latter fashion are perhaps better able to resist the winds than the former, because they afford it a free passage through the space between the butts of the grain. If the grain is bound thus at the time of cutting, it is necessary that it should not contain many weeds, otherwise it will be necessary to leave it in the swath for a few days.

Swath Shocks.—Swath shocks have this advantage over the sheaf shocks, that they may be made at any time and in any condition of the grain, dry or moist, clean or full of weeds. They are made in the following manner: Take a stake about four feet long, sharpened at one end, and pierced with two holes at the upper end, one above the other, so that two poles about three feet long, may be put into them in the form of a cross—place the swath grain in this cross, slanting it more and more until a cone of four or five feet in diameter at the base has been formed, then withdrawing the poles and

Digitized by Google

lifting out the stake, put on a cap formed of a reversed sheaf. If there be fear of winds, the cone may be surrounded by a band of straw a little below the heads.

In well made shocks, grain may be safely kept for months, in all weathers, and its preparation does not require much more time than the labor of binding, which is then done.

Having now adverted to the terrestrial, atmospheric, and agricultural causes affecting injuriously the productiveness of the wheat crop, in the present or preceding portions of this article, we will now proceed to a consideration of those causes of injury which we have seen fit to call constitutional, or those to which the wheat plant is by its nature exposed, and which, although susceptible of very great modification, by properly applied knowledge, are, nevertheless, in the present state of agricultural science, not wholly remediable by human ingenuity.

The simple diseases of wheat inherent in the nature of the plant itself, and not produced by something superadded, are but few and unimportant, but by nature wheat is exposed to the attacks of diseases whose ravages are very great, which are caused by agents which are independent existences, so to say; that is, by organisms which affect the plant by feeding upon its nutricious juices, and either destroying its vitality or perverting its development to such an extent as to make it unfit for the accomplishment of the purposes for which it was designed. These agencies are known as parasites, that is organisms which draw the materials for their nutrition and growth from some other organism, which they either injure or destroy by robbing it of its vitality for the support of their own being. These parasitic organisms are divided into two classes, vegetable and animal, and a description of the more prominent and important of the individual varieties belonging to these two classes, will make up the remainder of what we have to say in regard to the most important of all vegetable production, the wheat plant, and although we will be compelled to condense what might, from its importance, fill many

Digitized by Google

pages, into a comparatively small compass, yet we hope to be able to point out such practical and useful indications of the causes and cures of these maladies as to lead agriculturists to study more carefully the nature of these diseases, and their appropriate remedies, in order to make the production of the wheat crop a more certainly remunerative investment of time and labor than it is now.

Before entering upon a consideration of the diseases of wheat, caused by parasites, it seems proper to make a few remarks upon the subject of the

Degeneration of Wheat.—It has long been held in a traditionary manner that wheat degenerates, and that there is an inherent tendency so to say for wheat to change in variety in certain circumstances, but this is an error. The causes which operate to enable chess to supplant wheat are alike active to cause one variety of wheat to supersede another, and a reference to the arguments upon the subject of chess will be a sufficient guide as to the principle involved.

The more prolific varieties of wheat when mixed with the less prolific, bringing forth proportionally more grains, will in a few successive crops give a preponderance to the more prolific varieties, and in the end supersede entirely the others, and thus without one variety being transformed into another, the character of the crop may be entirely changed in a few years, by the presence at first of so small a number of grains of the less desirable but more prolific varieties, that their existence was unnoticed in the seed altogether.

The only means of preserving a variety of wheat pure, is to be exceedingly careful in the selection of unmixed seed, and if this be done continually no deterioration or change of variety can occur. The time will come, perhaps soon, when such a nice appreciation of the aptitude of different varieties of wheat for particular soils, will be attained, that, to obtain such varieties as are suitable for particular localities, wheat nurseries will be established for the purpose of procuring and

Digitized by Google

preserving all desirable varieties of seed wheat, as is now done to secure proper seed from which to raise plants of other genera.

Besides this mode of change in the variety of wheat grown upon a single farm or in a particular district, there is another mode in which wheat is gradually changed by the influences of soil, climate and manner of cultivation, as from red to white, from winter to spring, or awned to beardless wheat, and for such changes, if not desirable, a change in the mode of cultivation, as to manuring, plowing, time of sowing, etc., will prevent their occurrence, or if skilfully directed efforts are applied, favor such alteration in the character of the plant as may be desired; but, the easiest method, perhaps, of keeping up a particular variety of wheat is to import seed as often as deterioration is becoming evident, from some northern district where such variety grows habitually. Wheat assumes the character of a new variety, but very slowly indeed, under the influences of climate and soil, but yet such a change may in time be effected, as we have reason to believe that all varieties of the plant are the result merely of causes continuing for a long time in operation, and producing all the kinds of wheat now in cultivation from one or two original varieties, but no specific change has ever occurred in this plant, and all its varieties remain mere varieties, and could be reproduced again and again if lost, by a compliance with certain conditions, now known or yet to be known.

Vegetable Parasites.—Every creature which fixes itself upon another creature for support or nourishment, has received the name of parasite. Parasites pass through all or only a part of the phases of their existence, upon the individuals where they have been deposited in the shape of eggs, grains or spores. True parasites are those which live at the expense of the juices elaborated by the plants which support them, as the mistletoe, broom-tape, and a great number of mushrooms, etc., while the false parasites are those which merely find a point

Digitized by Google

of attachment and support upon the plant to which they adhere, and which thus live as well upon one individual as upon another, as the ivy, and various other creepers.

Among the false parasites we do not know any that have been remarked as causing damage to a great extent, although they are sometimes attached to grain, but it is not so with true parasites. But as most of these are cryptogamic plants, we will say a word in regard to the mode of reproduction of these singular plants, before entering into details, in order to make the following explanations intelligible to the reader.

Botanists divide vegetables into two great classes, viz.: those in which the organs of reproduction are visible or apparent, which they call phanerogamic, and those in which these organs do not appear and seem not to exist, which they call cryptogamic. For a long time the reproductive processes of several families of these latter, such as the *uredines*, *mucedines*, etc., was unknown; there was even a hesitation in deciding as to several individuals of these families whether they belonged to the vegetable kingdom even. But since the invention of convex glasses, and the attentive studies of the learned physiologist, Benedict Prevost, it can no longer be doubted that the molds, the rusts of plants, etc., are real vegetables, which, although they do not conform entirely like others, yet do not the less follow the same general rules of birth, growth and death, and of reproduction by seeds. And from the point of view of a philosophic study of nature, the mold which is cut with the edge of the knife in opening a loaf of bread, which is a little stale, while showing its roots, stems and branches, its flowers and grains, productions which could not have come into being except from a seed which has resisted the action of fermentation in the dough, and the heat of the oven, does not any less announce to you the supreme artist, than those beautiful productions which make the charm of the fields and the beauty of the garden.

If the dust of *caries* or any other *uredo* be spread upon the surface of water, maintained at temperature of 10° or 12°

Digitized by Google

Reaumur (55° to 60° Fahrenheit), each globule of the dust will be seen at the end of a few days, swelled to double its previous diameter, and then sprouting a tubercle five or six times as long as *it* is in diameter. This tubercle then divides at its extremity, into six, eight, or even ten branches, sometimes sessile and sometimes ramified. These branches still later present apparent articulations, or rather internal grains infinitely small, and at the same time the globules will appear withered and show reticulations, which without doubt previously contained the grains or sporules now developed, and which we can not refuse to regard as the seeds of the plant. The globules, then, which form the caries, rust, etc., of plants, are cryptogamic plants half grown, and which must be placed in other circumstances to complete their development. This being established, we will occupy ourselves with a separate consideration of caries, smut, and rust, the only parasitic plants recognized as injurious to grain.

To the foregoing concise description of parasites we will add, as a curious example of animal parasites, the following description of "Rust in Oats," not because of its being the appropriate place for considering this branch of the subject, but merely to give an example of the second class of these enemies to the farmer and the destroyers of his labors.

"*Rust in Oats*—*What is it?*—Throughout the whole southwestern portion of the Union, the oat crop has suffered from a terrible blight, which, from its resemblance to the fungus substance that sometimes attacks wheat by that name, has been called *rust*. So far as we are informed, rust in oats has hitherto been unknown. We have never heard or read of any thing of the kind, in any section of the country. The fact that it is thus unusual, opens a wide and interesting field to the naturalist, and in this case to the entomologist, as it invites investigation in a channel, so far as we can ascertain, heretofore unexplored.

"While in West Tennessee, a short time since, we took occasion to examine the blade of the oat under a microscope

Digitized by Google

(kindly furnished us by a friend), and were greatly surprised with the phenomenon which the glass revealed. Since then we have followed up those examinations, by the aid of more powerful instruments, at the Medical College in this city, in company with several scientific gentlemen, among whom were Drs. Briggs and Buchanan, of the medical faculty.

"The cause of all this destruction of the oat crop is a living worm, too small to be plainly seen with the naked eye. A single blade or leaf of the oat sometimes contains hundreds of them. They lie incased in the tissues of the leaf or blade, where they have been germinated, beneath the epidermis or thin pellicle over the exterior portion of the blade, and, as they progress in development, the skin of the leaf is raised into curious puffy blisters. The growth of the worm subsequently ruptures these, and it escapes to feed on the plant. When first released from their covering, they are of a beautiful, clear, red color, almost transparent, but soon begin to change color and form, getting more opaque and dark in appearance, until, in the course of transformation, they become a black bug, with legs and wings, when they attack the head or grain of the oats.

"Under the microscope, the dust which remains on the leaf closely resembles that on the wings of butterflies.

"How this innumerable army of infinitesimal worms originated, is yet a mystery. It is a singular fact, however, that wherever the greatest quantity of rain has fallen, there the oat crop has fared the worst. In our recent trip through West Tennessee, we saw but a single field of oats, between the Mississippi and Tennessee rivers, which was not a failure, or into which it would not be folly to put a scythe-blade. That field was near Denmark, in Madison county, and was sown very early. It is well known that more rain has fallen in West Tennessee this season than in any other part of the State; hence the extreme wet weather must have had some agency in the production of this animalcule. It is also well known that moisture and heat will produce and multiply ani-

Digitized by Google

mal life, millions per hour, and therein we judge is the secret of this destruction of the oat crop. It is one of those cases of natural phenomena which occur only at a certain stage in the growth of plants, and under peculiar states of temperature and weather. It may happen next season, or it may not occur again for many seasons."—*Southern Homestead.*

Vegetable Parasites.—We will now direct attention to that class of parasites which are of vegetable nature, and which are particularly noxious to the ceralia which are objects of cultivation. These parasites are all minute plants of the cryptogamic class, and are mostly microscopic, being in their individual magnitude so minute as to escape the scrutiny of the unassisted eye, but are yet in a state of aggregation not only discernible, but by their destructive influences upon the products of the farmer's efforts to secure a good return for his toil so terribly important, as to be but too well known when circumstances have permitted or favored their development in an unwonted degree. These minute vegetations are like all other plants produced from seeds or their equivalents, but unlike non-parasitic growths they only flourish when they find a vegetable which affords them a point of support, and already elaborated organic elements for their nutrition, while the others almost exclusively draw their nourishment directly from the earth and air, and combine its elements into their tissues and products.

Without attempting a classification of the vegetable parasites which are so prominently injurious to the wheat plant, we will describe some of the individual varieties; and first, that one which produces the disease known as

Mildew.—It often happens that a field of wheat which presented every appearance of a good return, is found near, or at harvest, to have been attacked by this disease, and suffers by it to the extent of loss, or damage, of one-half or more of the crop. We copy below, from Morton's Cyclopedia, a description: "Mildew, a word which is applied in various instances where plants or other substances, as paper, linen, glass, etc.,

Digitized by Google

are spotted with mold, or other minute fungi. The word, in its stricter sense, if it be true that it is but another form of the German *mel-thaw*, or meal-dew, should seem to indicate such molds as those which are so prevalent on the leaves both of trees and herbaceous plants, forming white, mealy patches; but it is by no means confined to them, and, indeed, is more especially given to a particular disease in wheat, altogether distinct from that with which vines and hops are so frequently infested. We will, then, first consider the white species, which exhibit, in general, very similar phenomena, though botanically distinct; and then briefly advert to the disease of wheat which is, in particular years or districts, so severe a scourge.

"The first kind, then, which is known to French gardeners under the name of *blanc*, or *blanc de rosier*, etc., is very widely distributed in one or other of its forms. Few natural orders of plants are altogether exempt from its attacks, but it is especially in peas, vines, hops, roses, and peaches, that it attracts the attention of the cultivator. Forest trees, too—as for instance the maple—when infested by it, are sometimes as white as if they had been washed with a coat of lime. The first stage of growth exhibits round, white, mealy spots, which are produced principally on the upper surfaces of the leaves, but extend likewise to the stems, and also to the floral envelops. There is some difference of opinion as to their origin; some botanists maintaining, that they are first developed within the tissues, and make their way through the stomata; while Leveille and Decaisne, in a late article in the *Revue Horticale*, maintain that they always originate externally, and that a previously diseased state of the tissue invariably exists. To this view, which has been stated more especially with respect to the mildew of the vines, we are not at present prepared to accede, as it is contrary to every observation that we have made, and to those of a very talented friend who had no previous knowledge of the subject, and, consequently, no prejudices to overcome.

Digitized by Google

"Be the origin, however, what it may, the spot consists of delicate, creeping threads, which usually radiate from the stomata, and give rise to erect articulated flocci, the ultimate articulations of which, at length become greatly constricted, and fall off in the shape of more or less elongated spores; these have the power of reproducing the plant. In this stage of growth they accord exactly with the genus '*Oidium*.'

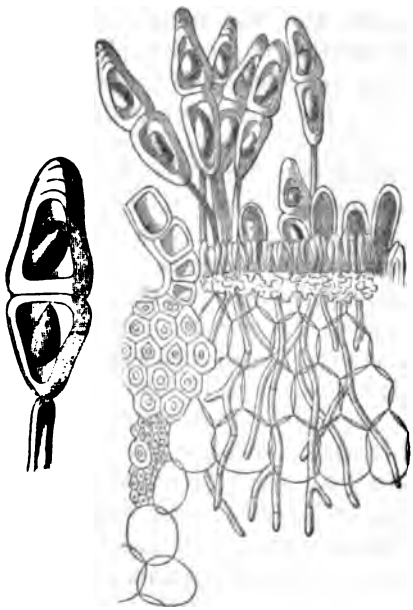


Fig. 26.

"The wheat mildew (Fig. 26), which is a very different structure, is a disease of a much more statistical importance in this country; its ravages, as in the harvest of 1850, being most extensive, and its effects, both in respect of produce and value, being most disastrous. The reduction of produce may safely be estimated, in mildew years, at one-half in badly affected crops; while the value of the produce is reduced from a fourth to a third. Unfortunately for this, the most formidable of the diseases to which corn (wheat) is subject, no remedy has hitherto been discovered.

"Wheat mildew is due to the attack of a parasitic fungus, which is developed beneath the surface from a branched mycelium, and makes its way through the cuticle in the form of a little black or deep brown sori, composed of clavate threads, divided above into two cavities, filled with a grumous mass,

Digitized by Google

and a large oil globule. In an early stage of growth, the swollen heads of the filaments are undivided, and it is then known to botanists by the name of *Uredo linearis*. A true *Uredo*--*Uredo rubigo vera* (Fig. 27), is frequently mixed with it, and therefore, has been supposed to be a mere form; an opinion to which we were once inclined, but which does not appear to be tenable. The discoveries by Corda and Leveille, of the mycelium of this and other allied plants, has completely established the fact of their being really fungi, and not mere alterations of the cellular tissue, as supposed by Unger; and this is confirmed by the circumstance that the spores may be readily made to germinate. Unfortunately, however, nothing is known as to their mode of propagation. The fact of mildew increasing so fast in foggy or damp, warm weather, is as consistent with the notion of the tissues being pervaded by something capable of propagating the fungus—whether in the shape of mycelium or granular matter, for the spores, from their greater size, could not possibly be there—as with the notion of propagation without; for in germination it is the spores themselves which germinate. Indeed there are very few wheat crops, be the reason what it may, in which mildew may not be found very extensively; but only in such atmospheric circumstances as are favorable to its growth, does it arrive at such a state of perfection as to become injurious.

Fig. 27.

Mildew is rare on other cereals, except wheat, but may be found most extensively on grasses and seeds, so as to make any preventive or palliative pains which may be taken, almost

Digitized by Google

hopeless. An able pamphlet was, indeed, written some years since, by Mr. Tycho Wing, the late very talented agent of the Duke of Bedford, Thorney, holding forth great hopes to the few farmers if they would clear their ditches of weeds and other grasses; and as the fields are usually cultivated to the very margin of the drains, there, if anywhere, such measures might be expected to be efficacious. It was very evident in 1850, and indeed has been a matter of experience formerly, that the lighter soils are more subject to mildew than those which are stiff and heavy, and that the earlier kinds of wheat are least affected. Heavy crops are always more subject, from the greater stagnation of air, than those which are light; but as the disease is seriously injurious only in certain years, and sometimes for several years together scarcely attracts notice, the farmer will not, probably, in the end, derive any advantage from attempts to guard against a heavy crop. Indeed, the best cultivated farms, at least in the district with which we are more immediately acquainted, suffered most during the late harvest; and we fear, therefore, must be looked upon as one of those unavoidable disasters which reduce the average of the farmer's profits, and which he must, therefore, previously take into calculation, be his skill what it may.

It has long been supposed that the berberry has a great influence in the production of the mildew, probably from the fact of its being very generally attacked by a fungus with rusty spores, which are supposed to communicate the disease. The structure of the two genera is so very different that this is scarcely probable, and when it is considered that the berberry in many districts is wholly unknown, and in others far from common, the strongest evidence alone can be considered as sufficient to establish the fact. Still competent authorities are much divided in opinion, and though in this country the notion has not met with much encouragement from scientific men, it is perhaps worthy of remark that a commissioner appointed expressly to examine the subject, by the *Royal* Agricultural Society of Lille—a town which has nurtured several

Digitized by Google

excellent botanists—came, after due examination, to the conclusion that the matter is not without foundation."

How far the remedies we shall point out for the prevention of other maladies belonging to the wheat plant may be applicable in case of mildew can only be determined by future experiment and observation.

Besides the above parasite there are several others of so much importance, that we will devote some pages to a description of them,—and the more particularly is this necessary, because they are more prevalent in this country than the one already mentioned. These diseases are all included by Corda in his work upon the subject translated for the American Journal of Agriculture and Science, by E. Goodrich Smith, under the German name "*Brand*," a blight, blast, or mortification, and are caused in all the cereals by a family of fungi "which natural historians call by the family name of the *Cœomaceæ*," one branch of which the *Uredines*, being more noxious than any others will claim almost exclusive attention. The *Uredines* infest all species of cereals and gramineæ, and give origin to the different appellations of *rust*, *smut*, etc., of which we will consider next in order the one called *caries*.

Uredo Caries, *De Candolle*, Fig. 28.—Caries, which is also called mildew, *caroncule* (an excrescence), *fouedre!* and still more frequently *ble noir* (black wheat,) scarcely ever attacks any other grain than wheat. This malady is due to a mushroom of the family *Uredines*, takes its origin in the interior juices of the plant itself, and does not appear to be capable of exterior communication. Half developed heads of grain have been sprinkled with caries, at different periods, and have never on that account shown any indication of the malady. The grains

Fig. 28.

Digitized by Google

which have been affected by caries, preserve very nearly their volume and their form, but the heads which bear them are known at a glance. They are straight, paler than the others, and the envelops of the grain, in which alone the malady is concentrated, are ordinarily so much spread, that they show this uncovered. The pericarp of the grain in place of inclosing flour, only contains a black material, greasy to the touch, and which attaches itself to the finger when rubbed. The spores of the caries are round, reticulated, provided with pedicels proceeding from a pulpy body which replaces the interior substance of the grain.

The dust of caries unlike that of smut, emits an unpleasant odor resembling that of the sea or of spoiled fish. This nauseous odor may even be detected in the bread made of wheat attacked by caries, the color of which it also hightens. The seminiform grains of the caries being in immediate contact with the grain in the head, attach themselves ordinarily to the hairs which garnish the extremity of the berry opposite the germ, and thus resist the action of the flail and even the winnowing fan, and it is only by means of an apparatus armed with brushes, to which the grain, in certain mills, is subjected, that this dust can be removed. The flour, although made much better by this operation, preserves some traces, nevertheless, of this dust.

The stalks of wheat which will produce carious grain, may be known as soon as they have sprung up, their leaves are of a deeper green than the others; somewhat later their stalks are tarnish (ternes-paded?) If a head which is attacked, be examined before it escapes from its envelop, the stamens will be found flabby, and the stigmas without fibrilla, and the embryo having already the odor of the caries. And as soon as the heads have shown themselves, it is easy to distinguish those which are attacked from those which are healthy. They are bluish, they have their husks more tightly closed, the embryo preserves its stigmata, and the anthers adhering to it are flabby and without pollen (dust). Soon afterward by the

Digitized by Google

progress of vegetation, the carious heads become larger, and become bristly, the grain increases in size, the pulpy substance which it contains takes an ashy color which soon passes into a brown.

There are frequently found sound heads upon affected stalks, sound grains mixed with carious grains in the same head, and finally grains half sound and half carious.

The following is, according to De Candolle and Benedict Prevost, the mode of procedure with caries upon the grain to which it is attached, or with which it is accidentally brought in contact in the field.

The grain swells more promptly when the ground is moist and the weather warm. The caries swells at the same time, sprouts its tubercles or branches, and finishes its evolution in a few days. It is then that the buds or seminiform sporules absorb with the nourishing juices of the plant, traverse its canals, and raising themselves slowly to the point destined by nature, even to the germ of the new grain, where they are separately developed, the only place where the circumstances necessary for their multiplication concur. The nourishment destined for the substance of the grain is absorbed by them; thus even a portion of that which should have formed the stamens and the pistil, which are consequently only imperfectly developed, but, what is a singular thing, that which serves for the growth of the pericarp (or bark of the grain), and of the husks, is not diminished, but is, on the contrary, augmented. Thus all the germs of the carious head enlarge by means of the caries itself, while there are a number in the healthy heads which are blighted. Hence the grains of the former are generally more numerous than the latter.

Caries attacks sometimes one-fourth, one-half, or even three-fourths of the grains. If the air in the vicinity of the sea seems opposed to rust, it appears, on the contrary, very favorable to caries. In the counties of Kamarouska, Temiscouata, Pimouski, etc., Lower Canada, this scourge decimates, nearly every harvest, the products of the wheat farmer. But

Digitized by Google

we may also say that no effort has yet been made to counteract this malady. And it is known that of all diseases of wheat, this is the easiest to control, because it has never been known to resist proper soaking of the seed in lime water.

If in a field the seed of which has been properly lime-water soaked, there are still traces of caries found, it is only due to seminiform sporules which may have remained in the ground at the time of harvest, and which particular circumstances have developed at the time of germination. Hence, again, the wise precaution never to sow cereals upon a stubble field attacked by caries.

One of the most efficacious and least expensive lime-water soakings is the following: Dissolve 1½ lbs. of sulphate of soda (glauber salts), in two gallons of water. When the salt is well dissolved, moisten or sprinkle the heap of wheat with a broom, taking care to stir it with a shovel until all the heap is moistened and the water begins to drip or run out at the bottom, then dry the heap with lime recently slacked and mixed with ashes, so that each grain shall be well impregnated and encrusted. Seed prepared thus may be kept a number of days, or may be sown immediately.

Sulphate of copper (blue vitriol), may also be taken in place of glauber salts, in the proportion of one pound to two gallons of water. This latter liming would be more certain than the former even, because the sulphate of copper being an active poison, would protect the seed from the insects which are in the habit of attacking it in the ground; seed prepared in this way may cause the death of birds which eat it; the fact has been tried and tested a number of times.

To the foregoing description of this parasite we will only add a few confirmatory or explanatory remarks. This parasite is known by its effects, under different appellations in different countries; it is called *Bunt*, Norton's Cyclopedia; *Pepper Brand*, Penny Magazine; *Uredo Caries*, De Candolle; *U. fœtida*, Bauer; *U. Litophila*, Ditmar; *Tilletia caries*, Tulume; and other species peculiar to particular plants, have been

Digitized by Google

named and described by various authors, under different names. (See Figs. 29, 30, 31, 32, and 33.) It has prevailed extensively and injuriously, but its nature and the means of preventing it being better known, it is to be hoped that its ravages may be entirely stayed in a few years, or at least to such a degree as to make them of very rare occurrence.

By reference to the accompanying plates, a quite clear idea may be formed of the microscopic appearance of this parasite, as these figures were all drawn from more or less greatly magnified views of the plant in different stages of its development.

Fig. 30 represents the spores of the *Tilletia caries* in various stages of growth. Fig. 31 the mycelium or filament. Fig. 32 germinating spores. Fig. 29 spores in situ. Fig. 33 part of the integument of a spore. Fig. 34 Fusisporium inosculans; all more or less magnified.

In reference to the preventive means we have already recommended, we will merely add that a writer in the *Country Gentleman* coincides in the recommendation we have given, to soak the seed wheat in a solution of blue vitriol, in the proportion of one pound of the salt to so much water as will cover four or five bushels of wheat.

The mode in which this soak operates is not only to destroy the germs or spores of the Uredo upon the surface of healthy grains, but prevents those grains which are diseased from germinating, and thus, even when the spores of the parasite are not themselves destroyed, the production of the stalk upon which they must depend for future development being prevented, they can not find the conditions necessary for their growth, and thus perish—while the vigorous and healthy wheat grains remain unaffected by the soak, and having no spores of the Uredo to support, produce only healthy heads. Thus it is not simply by destroying the spores of smut, but by preventing the conditions upon which their development depends, that the ravages of the disease are restrained.

Uredo Fœtida, *Pepper Brand*, Bauer—described in the Penny Magazine of 1833, coincides in general description

Digitized by Google

FIG. 29.

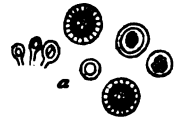


FIG. 30.

FIG. 31.

FIG. 32.

FIG. 33.

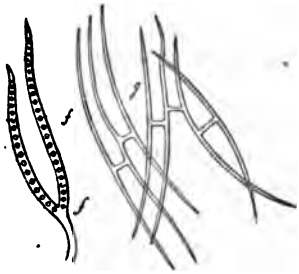


FIG. 34.

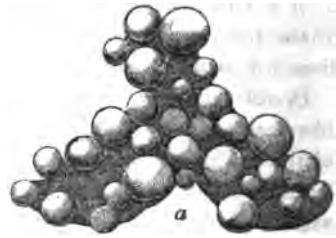


FIG. 35.

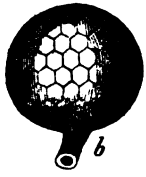


FIG. 35.

FIG. 36.

FIG. 38

Digitized by Google

and habits with what we have described as above as U. Caries, but the accompanying figures seem to point to another fungus of the same family. Whether these are distinct or are only seemingly so, on account of differences in the manner and time of observation, we are unable to state, and the determination of the question is of the less importance, as the same means of prevention are equally effective, whether there be two varieties or but one, as we are inclined to suppose, of this *Uredo*. Fig. 35 represents a group of this fungi on their spawn, magnified 160,000. Fig. 36 is a young fungus of the *Uredo fœtida* not quite ripe, at which time it can be separated with its pedicel *b* from the spawn (magnif. 1000 diamet). Fig. 37 is a ripe fungus (magnif. 1000 diam.) shedding its seed. These seem to us to be the same parasite as already mentioned, and that the difference is apparent only, and not real.

Uredo rubigo vera, De Candolle—Figs. 38 and 27.—Rust like the two preceding parasites; is a mushroom of the family of the *uredines*. It is developed upon both surfaces of the leaves, upon the stubble and upon the heads of the graminæ, with the appearance of little oval points, pulverulent, projecting, at first yellowish, and afterward becoming black. The little streaks which it at first forms in parallel lines at the side of the fibers, finally spread, and, joining, form large patches. When the rust attacks the grain only feebly, it does not appear to be very injurious to it, but when it is considerable, it occasions serious losses. Among all the graminæ wheat appears to be the favorite of rust.

If the streaks formed by the rust be attentively examined upon the stalk, but particularly upon the leaf of the wheat, the epidermis will be found split in every instance, and it will not be difficult to perceive that the sap extravasated by this split gives birth to the mushroom, or at least that it serves as a receptacle to the spores of this mushroom, raised from the ground by the rains, carried through the air by the winds, or, what is perhaps more probable, absorbed in the earth with the nourishing juices of the plant. It has been remarked that

Digitized by Google

the rust ordinarily shows itself when a very hot sun suddenly succeeds rains which have been somewhat prolonged. It is at the time when the evaporation of the water left upon the stocks and leaves, going on too rapidly, occasions cracks in the epidermis or vitreous varnish, which covers all parts, and thus permits the sap to deflect from its ordinary course, that circumstances favorable to the development of the mushroom are presented to its spores, whether they come from the interior or exterior. From the time, also, when a stalk of wheat is attacked by rust in a somewhat serious manner, it begins to languish; its leaves quickly begin to dry up; and when the rains are infrequent, the malady proceeds from the stalk to the head, which also soon turns red. The husk or nearest envelop of the grain then drying and adhering to this, soon occasions its decomposition, as much by the moisture retained by it as that which is maintained by the streaks of the mushroom fixed upon its glumes. It will not be rare in these cases to see fields of wheat produce less than half what they would have done without this accident.

The more, then, that heat and moisture permit the sporules or seminiform germs of the rust to attach themselves to the stalks of the grain, and develop themselves there, the greater will be the damage it may cause. There are certain places, as in South Carolina, for example, where the cultivation of wheat has had to be abandoned, because the natural humidity of the soil, conjoined with the mists, which prevail so frequently in that country, too greatly favor the development of rust. On the contrary, it has been remarked that, in the vicinity of the sea, or in grounds improved by means of lime or leached ashes, or manured with sea plants, the rust never exhibits itself in such abundance as to cause any considerable damage. The following seems to be the reason:

There is found upon the most of the graminæ, and particularly upon wheat, a certain shining varnish absolutely of the same material as glass. Most commonly this vitreous material terminates the edges of the leaves by little teeth, resembling

Digitized by Google

a saw of extreme fineness, but always capable of scratching the fingers of those who carelessly amuse themselves by frequently rubbing these leaves in the direction of their length. The greater then, the thickness of this glassy layer, and the stronger the stalk, the greater will be its resistance to the moisture or other atmospheric influences, which might cause it to crack and present false issues to the sap upon which the rust attaches itself. And it is imagined (conceived) that this layer of vitreous material will be stronger in proportion as the soil itself contains, or, as are furnished artificially, the elements of its composition. It is well known that to produce glass, sand is used, with lime and ashes, which are melted together by heat, although each one of these substances is scarcely fusible if heated alone. If, then, by mixing with the soil, lime, ashes, etc., there be placed at the disposition of the plant a greater abundance of the materials which enter into the composition of the vitreous material with which it is covered, it will necessarily absorb a greater quantity, and thereby place itself in better condition to resist the rust. The seaweeds, which, by their decomposition produce soda in quantity, which also enters into the composition of glass will produce the same effect. Thus, too, it has been remarked, that the rust has shown itself much more rarely in silicious or sandy grounds.

The rust is the less injurious to grain the nearer this has arrived at maturity at the time it is attacked by it. The damage which it receives only coming from the suppression of its nourishment which it (the root) intercepts to appropriate it to itself, or which it leads away from its ordinary channels, it (the grain) suffers the more it has great need of this nourishment.

As grain ripening early is rarely attacked by rust, and as this does not ordinarily show itself until toward the end of August, or the beginning of September, perhaps a certain continuity of heat is necessary for the development of its

Digitized by Google

seeds, a heat which it can not meet in July or the commencement of August.

There has been no means used, so far as I know, to combat the rust in Ohio. There has been more reason to complain of it than ever in the district of Quebec during recent years, since particularly to escape the fly, the sowing of spring grain has been postponed until the commencement of June. The vicinity of the sea, in general, preserves the districts of Gaspe and Kamouraska. There ought, then, in the places where the rust is most to be complained of, after all necessary care of the ground by good drainage, be used as much lime and ashes as possible as a manure, and a field of stubble where rust has made an attack, ought not to be sown, and besides the seeds ought to be limed as described above.

Smut.—(Du Carbon), *Uredo segetum De Candolle.* Smut, like caries, is a parasitic mushroom of the family of the *uredines.* It is pulverulent, like all mushrooms of this family, and it destroys or replaces the organs in which it is developed. Smut has often been confused with caries and rust, although its characters are sufficiently distinct to make it readily distinguishable from one and from the other. In several places the name mildew is also given to the smut.

Smut sometimes attacks the leaves and stems of the plants, but it is the grain itself which it most commonly invades. Smut attacks all the graminæ, but seems to prefer oats, barley and maize. In a field one can scarcely distinguish the stalks affected, except by a little less hight, and a somewhat tarnished or somewhat paler color. So long as the head has not emerged from its envelops, the diseased portions appear in almost their natural condition. But as soon as the head has separated the leaves which it hid from sight, it appears of a pale gray, and in a short time it assumes a black or coal-like tint. The floral envelops, the pedicels, the glumes, are all altered, changed or consumed; it is often difficult to recognize even a vestige of the grain. It blackens the fingers

Digitized by Google

of those who touch it, and falls into powder if it is shaken; this powder is inodorous.

The seminiform sporules of the smut, which are infinitely small, and still lighter than those of rust and caries, are also produced in the interior of the plant. The proof of this is, that the heads are found entirely destroyed by the smut, even before they emerge from their envelops; the seeds of the mushroom absorbed in the soil with the alimentary liquids of the plant having found in the head the circumstances favorable to their development.

Smut is disastrous for the farmer when it attacks a great number of heads. Fields have been seen in which it had attacked one-fourth, one-half, or even two-thirds of the heads of grain. All the heads from the same root are smutted, sometimes all the grains of the same head are not, but such grains are always small, lank and withered. The smut is developed as well in a dry as in a rainy year, and as well in a dry as a moist soil. But it has been remarked that where it made the greatest ravages was always in little fertile grounds or such as had the year preceding produced a graminæ affected by smut. In the first instance the vegetative life being enfeebled, the mushroom met less resistance to its development, and in the second, the ground having retained the spores of the mushroom, of the preceding year, it already contained the elements of the malady.

The remedy would be then, first, a lime-water soaking to rid the seed of the spores which may be attached to it, and, in the second place, not to sow grain upon any kind of cereal stubble which had been attacked by smut.

It is not probable that the smut can be injurious to man by the use which he may make of the grain which shall have been attacked by it, because at the time of harvest the spores of the mushroom have in a great measure, left the grain, and because threshing and winnowing will remove the remainder. According to several authors, even the straw of smutty heads

Digitized by Google

although of an inferior quality, would not be prejudicial to cattle fed upon it.

Smut, so far as known, has never been the cause of great damage to the Ohio farmer. It is believed that there have rarely been seen fields of wheat in which more than one-hundredth or one-sixtieth of the heads were attacked by smut. This is doubtless due to the vigorous vegetation which characterizes our climate, and perhaps also to the custom almost general in this country, to alternate fallowing and cultivation.

A statement has found its way into the agricultural papers to the effect that seed wheat, threshed by a machine, is the cause of smut in wheat; and to prove the assertion, a case is given of seed sown which was threshed by a machine, and an adjoining land or two was sown with wheat threshed by hand; that the result was that the machine-threshed was smutted, while the hand or flail-threshed was free from smut. The *cause* attributed is that the machine breaks the grains, and when sown the young plant has not sufficient nourishment to grow a *perfect* plant, and hence is diseased.

It is not true that a broken grain of wheat produces an unhealthy plant. If a plant is produced at all it will be a healthy plant—although it may not be a *vigorous* one, yet it will be perfect and healthy. If the chit or embryo is uninjured it will grow, and when the amylaceous portion of the seed is exhausted, the young plant will find its nourishment in the soil. But if the amylaceous or starchy body is exhausted before the plant is sufficiently developed to elaborate its own nutriment, it will die. If breaking the grain of wheat produces diseased plants, then by an unexceptionable analogy and parity of reasoning, cutting potatoes to plant should produce diseased potatoes—a conclusion neither confirmed nor corroborated by experience.

But it is very possible that the starch cells of the broken grains, having an organic vitality which is called into action by being sown, having to expend their energies in accordance

Digitized by Google

with physiological laws, and having no embryo to nourish, may produce *fungi*, which by alternate generation may become smut, or some other species of uredo. It certainly is better policy, if not absolute economy, to sow seed which is not only perfect but is perfectly clean.

We are indebted, says the *Cincinnati Gazette*, to Mr. R. G. Carmichael, Commission Merchant of this city, for the following valuable information with reference to the preparation of seed wheat. The process has been fully tested by farmers in England and Ireland, with entire success:

"*To Prevent Smut in Wheat.*—Dissolve half a pound of sulphate of copper in three quarts of warm water. After the mixture has cooled, sprinkle it over two bushels of wheat, stirring it through until the whole be wet. Put it up in a heap, turning it occasionally for an hour, when it will be ready for sowing. Should wet weather or any other cause prevent its being sown immediately, spread it thin on a dry floor, giving it an occasional turning, and it will not suffer injury for weeks."

The above was received from a very intelligent as well as extensive farmer and miller, who says in regard to it:

"Where this has been carefully carried out, it has been found effectual in *preventing* smut in wheat. Of course, no man should sow smutty wheat, but even smutty wheat will produce grain perfectly free from smut, if it be carefully dressed as above. The reason that sulphate of copper produces this result, is, that smut, being a fungus, which, when the balls are broken, attaches itself to the ends of the wheat, in many cases kills the wheat and grows in its place. The solution kills the fungus, but is not powerful enough to hurt the wheat. Care should be taken to prevent any animal from eating grain dressed with this preparation, as it is poisonous."

The editor of the *Gazette* says the solution kills the smut, but is not powerful enough to hurt the wheat. That is much like asserting that arsenic in large doses will kill a tape worm, but not hurt the individual who is so unfortunate as to have

Digitized by Google

a tape worm. The truth is, that whatever will kill smut will most assuredly kill the wheat.

The editor very properly calls the smut a fungus, but he should know that the fungi are among the very lowest types of vegetable organizations, and are possessed of a vital tenacity exceedingly remarkable. The yeast which our good housewives use in leavening bread is a fungus, and we all know that it can be taken, when in the hight of its development and multiplication, reduced to a solid, kept at a temperature below zero, and so kept for months, but when surrounded by the proper conditions, it immediately vegetates. The *protococcus*, or red snow, grows, developes, propagates, and flourishes, on the snows in the northern part of Greenland—it is a fungus.

In our experiments, we have placed smut balls in a solution of nitrate of potash, dilute nitric acid, sulphate of iron, sulphate of copper, sulphate of zinc, and even in dilute sulphuric acid, but the smut so treated invariably manifested undoubted signs of vitality when surrounded by proper conditions.

We do doubt the assertion that W. Carmichael's plan above mentioned, produces uniformly clean wheat, or prevents smut in wheat—because even if his theory is true, it is almost impossible to moisten *every* smut ball. The better plan is to make a solution of, say, one pound of *blue-stone* (sulphate of copper, or blue vitriol) to two gallons of water; put the solution in a tub or other wooden vessel; then put in wheat to within two or three inches of the surface; stir it well, and then let it stand an hour or longer; at the expiration of this time, the light (diseased) grains of wheat, as well as the smut, will rise to the surface, and may be skimmed off; after the wheat has been taken out of the vessel, it should be spread on a dry floor, and thoroughly sprinkled with recently slaked lime—if necessary, it may remain in this state several days before sowing.

The few smut balls that remain attached to the sound and healthy grains during the steeping process have become suffi-

Digitized by Google

ciently moist to germinate, and the lime forms a proper *nidus*, and nearly all the smut balls will be found to have germinated in the course of forty-eight hours, but finding no substance in proper condition to nourish them, they necessarily perish, and thus the wheat is prevented from being smutted, but not because the solution kills the smut and not the wheat.

Before leaving this part of our subject, it is well to remark that very many fungi of different species infest the other members of the vegetable world almost without exception, and compose a large class of plants called *cryptogamia*, because the organs of reproduction are not distinguishable to the natural eye. The varieties of these fungi are very numerous, and it is impossible in the limits of this report to describe, or even name all of them, and our aim has been merely to point out those most important, on account of their extensive ravages.

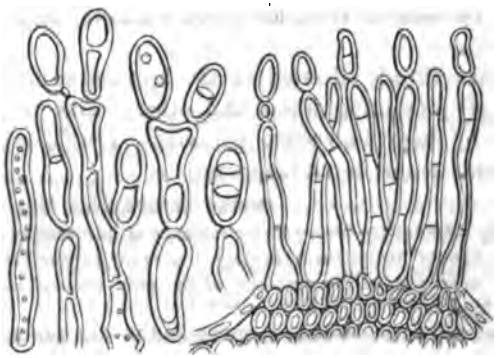


FIG. 39.

Cladosporium Herbarium, Fig. 39, highly magnified, is a black fungus which sometimes gives a dingy appearance to whole fields of grain. It is often called mildew, but never attacks wheat except it has become already diseased. The appearance of the straw attacked by this fungus is shown

Digitized by Google

Fig. 38, slightly magnified, the dark patches indicating the diseased points, or those upon which the Cladosporium has formed lodgment.

The *Uredo rubigo* already described, is figured in Fig. 27, highly magnified, and is one of the most important of the *uredines*, as its ravages are so great under favoring circumstances as to destroy one-half or two-thirds of a crop of grain, and sometimes even more, and might, by extensive prevalence, be the cause of a serious scarcity of grain, and it well deserves the careful attention of the agriculturist.

The *Uredo fœtida* also described, is figured in Fig. 28, highly magnified, and is also an important member of this destructive family of parasites, which have received their names from the peculiar effects upon the plant attacked. *Uredo* and *Brand* are derived from words in Latin and German, signifying *burning*, and corresponding to our words *blast*, *blight*, and the burnt or rusty appearance of the plants attacked by some of these has given rise to the English term *rust*.

We have already adverted to the best means hitherto discovered of preventing wheat and other grains from being attacked by these destructive parasites. The following from an authentic source is not inappropriate.

PREBLE COUNTY, Ohio, May 7, 1858.

JOHN H. KLIPPART,—*Sir*:—At the instance of our worthy Secretary of Preble County Agricultural Society, I give my personal observation as to the operations of the *rust*, one of the most ruinous diseases the crop is subject to.

In 1842 I had a large field seriously affected by rust, and having read in the Genessee Farmer the necessity of early cutting, I put a hand-cradle to work and left—was absent a few days, and on my return found my hand had only cut a few dozen sheaves—avowed that it was so green he knew it would be worthless. I then procured hands and had the field cut, but too late for more than a *half crop*, while the portion cut at first was plump, and had well filled grains.

In 1849 I had three fields of wheat of equal size—about the 20th to 25th of June the rust made its appearance in its worst form. The cholera being in the country, hands were hard to procure. I, however,

Digitized by Google

procured two cradlers, and set them to work in field No. 1; soon left for the day, and on my return home was vexed to find my foreman had abandoned the field, with the declaration that if I was d—d fool enough to cut wheat so green, he was not. I explained and entreated, and finally got the field cut on *Monday* and *Tuesday* of the week, leaving the wheat in the swath unbound, until it partly cured in the sun before binding. Field No. 2 was left, partly to meet the views of my hands, and partly to mark the difference as an experiment, until Thursday and Friday, when it was cut and shocked. Field No. 3 having been put in by a tenant, and under his control, was left until the Monday following, though I urged him to have it harvested sooner. On Monday all hands were ready for the work, but on close inspection there *was nothing* but straw to cut, and hence the field was left unharvested.

THE RESULT.—Field No. 1, although it was the poorest set or stand by at least one-fourth, produced 12 measured bushels of wheat to the acre, weighing 56 lbs. to the bushel. No 2 yielded 8 bushels to the acre, weighing only 46 or 48 lbs. to the bushel, while the third field, fully equal to the second field in every respect, and the same kind of wheat (white chaff beardy) produced *nothing*.

The rust in '49 produced general havoc in this county, thousands of acres having been entirely destroyed. And *ignorance* as to the time of cutting when the plant was thus afflicted, must have bled our county of at least $50,000, if not double that amount. For all who cut any portion of their grain in the incipient stages of the rust, received a fair yield, varying in quantity and quality as to time of cutting. Again, in 1857, last year, the rust made its appearance, but not so fatal in its consequences, but enough to do great damage. So soon as discovered I "pitched into" field No. 1, cutting and shocking the same day. The crop was so green I had to re-open the shocks and many of the sheaves to cure them, to keep them from molding, as I also did in field No. 1 in '49. Field No. 2 was left a week, being a later sown field. And again had a field, No. 3, in charge of a tenant who obstinately refused to cut till ripe. Result.—No. 1 produced 25 bushels to the acre: weight 64 lbs. to the bushel, and as full, flinty wheat as I ever saw—No. 2 being only a half set by "fly" and "freezing out," produced 10 bushels to the acre, and weighed 56; but in this field, and on the poorest point in it (clay land) I had well manured one acre in center of the field, and on which was at least 30 bushels of No. 1 wheat, neither the rust nor fly had affected it. No. 3 yields (though a good set) some 8 bushels to the acre, and the wheat so poor it could not be sold; I am using it for feed. I think it a fixed fact, that the *rust* detracts or draws the *substance* from the *grain*.

GEO. D. HENDRICKS.

Digitized by Google

CHAPTER XXI.

ANIMAL PARASITES AFFECTING THE WHEAT.

The animal parasites affecting the different species of plants which compose the vegetable kingdom, are very numerous, and very widely different in their character, habits, mode of attack, and importance to man as destroyers of the fruits of his labors, in the garden, orchard, field, and vineyard. We can not advert to any except those most important, on account of their extensive depredations, and can only recommend to all persons, whether directly or indirectly interested in the productiveness of our agricultural labors, to contribute, so far as possible, to the general fund of information concerning these enemies of man's comfort and prosperity, by studying practically the subject of entomology, and recording their investigations in regard to any or all classes of insects which may come within their scope of observation. In this manner we may hope to gain such an acquaintance with the nature and habits of noxious insects as will enable us to counteract their deleterious influences and restrain them within safe limits, if we should not succeed in entirely eradicating their species, and thus preventing the necessity of further watchfulness in regard to them.

In the following descriptions we have not always been able to point out a remedy for the evil described, but it goes far toward discovering a remedy, when the disease has become fully known, and we may venture to hope that a knowledge of the means of preventing the destructive ravages of some, at least, of these terrible scourges, may soon be gained by some persons among the many whose interests they so greatly and injuriously affect.

Agrypnus Murinus (Mouse-colored click-beetle).—Is the parent of a wire-worm with a flat and indented tail; it is generally found under stones, and probably feeds on the roots of grasses. The beetle inhabits wheat fields, and sandy situations during the spring and summer. It is broad and flattish, clothed with short ashy hairs, marbled with brown; the two horns are short; the six legs are of a pitch color, tips of the

Digitized by Google

thighs and feet tawny; the wing-cases conceal a pair of ample wings; it is six lines long, and two and a half broad, or larger.

Agriotes Lineatus (Striped click-beetle).—The head and thorax are brown, clothed with cinereous down; the wing-cases are of a fulvous color, with nine punctured lines, forming four brown stripes on each; the horns and legs are brighter brown. It is abundant in wheat fields, grass lands, hedges, under stones, etc., from March to July.

A. Obscurus.—The obscure click-beetle is of the same size and form as the last, but it is of an uniform earthy-brown color. This beetle is abundant in fields, gardens, pastures, and woods, from April to July.

FIG. 40.

FIG. 41.

A. Sputator.—The pasture, or spitting click-beetle, is much smaller than A. obscurus; the head and thorax are black, thickly and distinctly dotted; the latter often has the anterior margin and hinder angles—which form short, stout points—rusty; the wing-cases are light brown, with nine dotted lines on each; the entire surface is covered with ochreous down; the horns and legs are reddish brown, Fig. 40 (2), and magnified at Fig. 41 (3); it is universally abundant, from the end of April to the beginning of July, in wheat fields, hedges, and pastures, especially after floods. These four elators, or click-beetles, are the parents of the true "wire-worms," whose history will be more fully given under that head. Their economy is now pretty well understood; the eggs appear to be laid close to the plants destined to support the young maggots, when they hatch; the larvæ live upon various roots, entering the stems occasionally, and forming burrows in the soil.

They must be exceedingly minute when first hatched; and as the different click-beetles vary in size, their wire-worms, no doubt, vary also.

The small one, Fig. 40 (1), we consider to be the offspring of A. sputator (2) and of A. lineatus. When full grown, the wire-worms form a cell deep in the earth, and change to pupæ. At this period of its existence, it is in a torpid state, and lies buried, as it were, in a tomb, until the appointed time, when the spring sun warms the earth, and all the limbs being now perfected, the beetle bursts its shroud.

Digitized by Google

forces its tomb of earth, and makes its way to the surface, to dry and expand its wings and limbs, when it is again prepared to generate its species. The click-beetles have the power of springing up when laid on their backs.

Anisoplia Agricola (Field Chafer), is a small species of cock-chafer, which does considerable mischief to wheat and rye when they are in the ear, by congregating upon the milky grain, and eating out the contents.

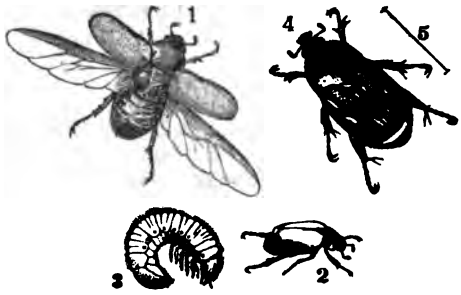


Fig. 42.

This beetle is abundant in France and Germany, but it is very rare in England; it is of a bottle-green color, the nose is narrowed and curved up; the horns are short, terminating by a little club cleft into three lobes; the wing-cases are shorter than the body, either ochreous, with a blackish square spot at the base, a splashed line across the middle, and the margin irregularly black; or they are bottle-green, with ochreous spots; Fig. 42 (4)—(5), the natural length; the six legs are very strong, spurred, and terminated by unequal, acute claws.

A. Horticola (Garden Chafer, or May-bug), is a similar insect, and very abundant in this country. It flies well, and often covers the white thorn hedges and wheat, making also sad ravages in gardens in May and June, by destroying the flowers and leaves of roses, apples, peaches, etc., feeding upon the parts of fructification, and riddling the foliage. It is of a very glossy green, but the wing-cases are of a tawny color. Fig. 42 (1)—(2), the same magnified. The female beetle enters the earth to lay her eggs, and is thus the parent of a maggot, Fig. 42 (3), which is very destructive in pasture lands, feeding upon the roots of the grass, causing large patches to wither, and rendering the turf spongy, and often unproductive to a great extent. These grubs, as they are called, are of an ochreous white color, covered with rusty hairs; the head is shining and deep ochreous, jaws strong and black at their tips; the six pectoral legs are longish, and the extremity of the body is soft and of a lead color. They are feeding for many months before they arrive at maturity, when they retire a considerable depth, to form earthen cells and undergo their transformations—first into a pupa, then into the perfect beetle.

Sparrows will gorge themselves with the beetles; blackbirds and

Digitized by Google

thrushes pick them up as they emerge from the soil, and starlings turn up the loosened turf to feed upon the maggots.

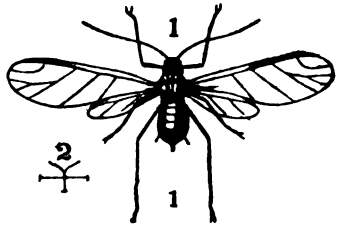


FIG. 43.

FIG. 44.

Aphis Granaria (Wheat Plant Louse), inhabits corn crops, having been observed upon barley and oats, as well as upon wheat. In July and August it is sometimes abundant on the ears of wheat, sucking the stem and impoverishing the grain. The male is green, Fig. 43 (1)—(2), natural dimension—horns very long and black; eyes and three ocelli black; disc of trunk dark; tubes slender, longish, and black; nervures of wings pale-brown; terminal cell semi-heart shaped; stigma long and green; hinder legs very long; thighs—excepting the base, tips of shanks and feet—black. Females often apterous (wingless), dull orange; horns, excepting the base, eyes, and abdominal tubes (which are stouter than in the winged specimens), black; legs blackish, anterior thighs, and base of tibiæ, more or less ochreous.

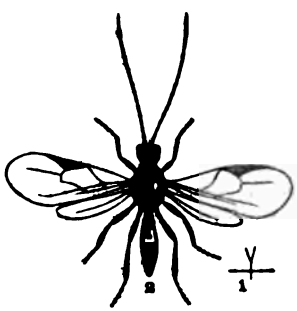


FIG. 45.

FIG. 46.

Numbers of the apterous females are often seen dead, and of a tawny or black color, upon the ears of wheat; having been punctured by a parasitic fly, named Aphidius avenæ, Fig. 45 (2)—(1), the natural size, which escapes when it hatches by forcing open a lid at the under side of the body. Ephedrus plagiator, Fig. 46 (7)—(8), natural dimensions.

Digitized by Google

is a similar parasite, bred from the dead females, which turn black when punctured, as shown at (3)—(4), Fig. 44, being the natural size.

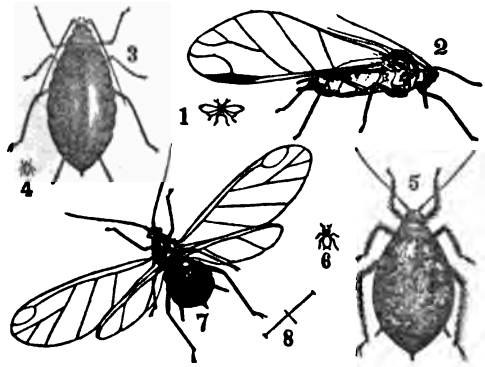


Fig. 47.*

A. Zeæ (Indian-corn-plant louse), appeared in August, in groups beneath the leaves of some maize grown in this country; but they disappeared about the middle of September, when the cold nights set in. It is a pretty species, very distinct from any of the others, and is probably abundant in the southern countries of Europe, where the maize is regularly cultivated. First the apterous females appeared, Fig. 47 (5)—(6), natural size, with the head, collar, base of trunk and of horns ochreous; the other joints brown; eyes black; the back dark-green, marbled with a paler tint; extremity of body rosy; tubes rather short and far apart; legs ochreous and hairy; feet and tips of shanks brown. They were surrounded by little groups of their offspring, of a dark-green color; afterward a few winged specimens appeared, Fig. 47 (7)—(8), natural expanse; they are of a pale, rosy tint, variegated with green; the long, slender tubes, fine horns, and legs, are whitish; feet, tips of thighs, and shanks, dusky; nervures of the wings very pale; stigma pale-green or colorless.

Athous Longicollis (Long-necked click-beetle), is often found in wheat fields in spring and summer, and is produced from a wire-worm; but whether it is injurious to the crops, has not been discovered. The male is narrow, of a fulvous color, the head and trunk are black and punctured; the latter is longish, with the margins rusty; the scutle and

* Fig. 47—1, 2, 3, and 4, is the A. humuli, or hop-beetle, erroneously introduced by the engraver.

Digitized by Google

breast are blackish; the wing-cases have eighteen lines of dots; and the outer margin is brown; beneath them is an ample pair of wings; length four and one-fourth lines. The female is broader, larger, and varies in color, from an uniform brown to an ochreous chestnut tint. A. niger (black click-beetle) is polished, black-clothed, with shining yellow hairs. It is elliptical, finely and not thickly punctured; there are eighteen fine furrows drawn down the back of the wing-cases, which cover wings for flight; length half an inch. It is very abundant in May and June in cornfields, meadows, and hedges; the wire-worm is said to live in very rotten horse muck.

A. Ruficaudis (Red-tailed click-beetle), is a species so abundant in cornfields, from April to July, that its wire-worm is no doubt very destructive, and it is supposed to resemble those of Agriotes lineatus, and A. obscurus, except that it is larger. The beetle is downy, with short ochreous hairs; the head and trunk are black, and very thickly punctured; the wing-cases are hazel-brown, with eighteen punctured furrows; the wings beneath are ample, and it is often seen flying; the legs and under sides are reddish-brown, the trunk and breast darker, often blackish; it is six lines long.

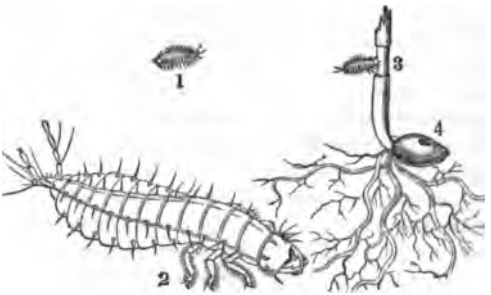


FIG. 48.

Bembidium.—A genus of minute beetles. A small larva has been detected doing considerable mischief to wheat crops, which is supposed to be the offspring of a Bembidium, or of a Staphylinus. It is a little creature, Fig. 48 (1), with strong jaws; minute horns and eyes; six hairy, jointed legs, with simple claws; the tail is tubular, and furnished with two jointed horns; and there are four series of spines down the back and sides; seen in (2) when the insect is magnified. In October these larvæ have done great injury; the young wheat plants dying off fast, owing to their cutting round the outside sheaths of the stem (3), about an inch below the surface of the soil, to feed, it is supposed, upon

Digitized by Google

the root and tender straw. On being disturbed, they run into a hole previously formed by them in the husk of the seed wheat (4). One-fifth of a crop has been destroyed by these animals in Suffolk.

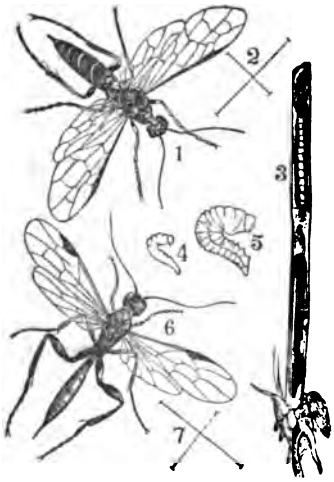


Fig. 49.

Cephus Pygmæus (the Corn Saw Fly), is often not uncommon in our cornfields, and abounds on umbelliferous flowers, and the long grass which springs up on the surrounding banks in June, and early in July. The females, Fig. 49 (1), natural dimensions (2), which are most abundant, lay their eggs in the stems of rye and wheat, either below the first joint, or just under the ear. The young maggot consumes the inside of the straw, ascending and sometimes perforating all the knots before it is fully grown, when it descends to the base of the straw and cuts it down level with the ground at harvest time; the maggot in its case (3). It immediately incloses itself in a transparent case within the stump of straw, a little below the surface, and closes its cell with excrement and bits of food.

There it rests secure through the winters, and in March it changes to a pupa, and is transformed to a saw fly, occasionally as early as April. The maggots (4) magnified at (5) are fat, wrinkled, and yellow, with a darker head. The flies are shining black, with a yellow membrane on the neck and at the base of the abdomen, across which are two yellow rings and a spot in the male; the tip is also yellow, as well as the mouth, hips, inside of thighs, shanks, and feet; inside of hinder shanks and feet brown. Female larger; two horns shorter and stouter; four wings smoky; face black; abdomen compressed, with a short black oviduct at the apex; hips and thighs black, tips of the latter yellow (1). A parasitic ichneumon, called Pachymesus calistrator (6), natural dimensions (7), infests the larvæ of the Cephus.

No doubt clover crops encourage the wire worms, and clean fallows diminish their numbers; and various checks to their increase may be called to our aid in the cultivation of land, such as hard rolling after a top dressing of lime, mixing spirits of tar, gas, lime, nitrate of soda, or

Digitized by Google

rape cake, with the soil. A crop of white mustard or woad it is supposed, will drive them away, and mowing corn is believed, by some agriculturists, to banish them. If artificial means be resorted to for their extirpation, it has been proved that hand picking, tedious as it may seem, is the most effectual, and not a very expensive mode of clearing the land of these pests.

A little fly (Proctotrupes viator) insinuates itself among the loose earth, to deposit its eggs in wire worms, and other subterraneous larvæ, and does considerable service; but it is on birds the farmers must depend for assistance.

The crows, lap-wings, gulls, starlings, pheasants, partridges, black birds, thrushes, wagtails, and robins, can all make a meal of wire worms, and even the poor mole is most serviceable in this respect.

Cecidomyia Tritici (the Midge or Red Weevil)—Is an insect belonging to the same genus as the Hessian fly, and at the same time that the family resemblance is quite apparent there are specific differences in the appearance and habits of the Hessian fly and the midge, which separate these two members of the same family into quite distinct species, and renders separate description of these two exceedingly injurious insects necessary.

The Cecidomyia tritici is ascertained to be the true cause of the failure, to such a great extent, of the wheat crop in Ohio during the past few years; and it has, consequently, attracted unusual attention from farmers, where the wheat crop has been found greatly deficient in well-developed grains, on account of the ravages of this insect, which causes an abortion of many of the grains in a head attacked by it, leaving the grains which were not affected to mature healthily. This infertility of part of the glumes upon a head of wheat was formerly supposed to be due to atmospheric influences entirely; but this has not been a well-ascertained cause, while the influences of the *midge* are well established as a definite cause of a partial abortion of the wheat heads, by destroying the fertility of all the glumes upon which it has made its attack. This assertion has been verified by very extensive observations in many departments of France.

To describe this insect, heretofore so little known, and to note its character and ravages, and means of prevention, if such there be, is an important entomological labor, and a careful examination of the whole question involved is of vast importance to every individual, as upon the existence or non-existence of the larvæ of this parasite in our wheat fields, where they may be found within the glumes about the time of flowering, depends much human comfort or misery, small as the insect is. And men whose modes of life present them with favorable opportunities for inves-

Digitized by Google

tigation of these matters of interest, should improve their opportunities for the advantage of themselves and fellow-beings.

The *Cecidomyia tritici* (improperly named *wheat weevil* by some persons; this last name is more appropriately applied to the *Calandra granaria*, hereafter to be described), is a small yellow fly, commonly called "*The Midge*," which makes its appearance about the middle of June, and can be met with until the middle of July.

Fig. 51.

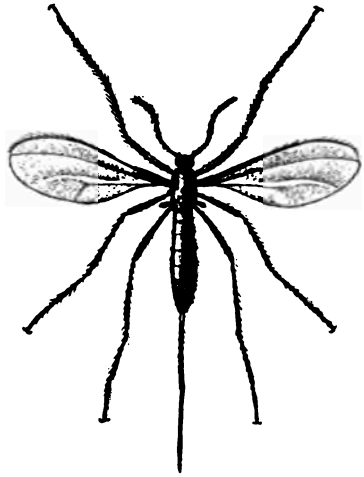


Fig. 50.

Fig. 52.

The *female Cecidomyia tritici* much enlarged,—the figure to the right is a view of the ovipositor magnified.

Toward sunset they leave the lower part of the wheat stalks upon which they had taken shelter during the day, and may be see in myriads about the flowering time of wheat, when they sally forth during the early part of the evenings to deposit their eggs in the glumes of the wheat, just before it blooms. They remain on the wheat heads during the night; and sometimes two or three of them may be found depositing their eggs upon the same glume. They resemble common gnats somewhat in appearance, and are classified with them in entomological descriptions The body is less than one-twelfth of an inch long, of a citron yellow, or sometimes inclined to orange. The eyes are proportionately very large, and jet black; the wings are long and transparent. The female has a long ovipositor, about the size of the thread of the silk-worm (see Fig. 52), which she thrusts into the same place between the glumes of the spike-

Digitized by Google

let as that from which the wheat grain is to spring (see annexed Fig. 51), where the eggs are sheltered, hatched, and nourished. This deposit begins when the wheat head emerges from its sheath of leaves, and is terminated when the head is in bloom; after which they never deposit their eggs, as the grain will be far too advanced to furnish the larvæ their nutrition if deposited after flowering. Tardily flowering heads still continue to be attacked, and thus the process of deposit continues from about the middle of June until in July.

The larvæ, when hatched, are white, but soon become yellow, and have been found in numbers from fifteen to twenty upon a single kernel of wheat, from which they derive their nourishment, and thus prevent the development of the grain upon which they feed. If the number of larvæ in a single glume be large, ten or more, the material for the formation of the grain will be entirely absorbed; but if only a small number be present, they merely divide the nutritious materials with the grain, which is then partly developed, as seen in the figure of a defective grain (see Fig. 53). They begin their injurious work when the grain is in the formative state, and continue it until the milk hardens, and they produce a livid, spotted, or faded appearance of the glumes infested by them; but this change of appearance becomes less marked as the head ripens, although the injured glumes turn yellow more rapidly than the healthy ones, as the natural humidity of a perfectly-formed grain is wanting to delay the drying of the glume. The engraving (Fig. 54) shows the larvæ surrounding the young grain.

Fig. 53.

Fig. 54.

The larvæ, to attain their perfect development, must reach and take shelter in the earth; and to do this, they bend themselves into an arc, and, like the so-called skippers in a cheese, spring out and fall to the ground. Some of the larvæ remain in the heads, as exceptions to the rule, and attain a perfect development the following year after having wintered in the barn. Those which reach the earth, which they do just before or at the time of harvest, seek shelter near the roots of the wheat stalk, and, burying themselves to a slight depth beneath the surface, lie dormant until the next spring, when they assume the pupa, then the imago, and lastly the perfect form, about the middle of June, as already stated, and may then be found resting on the ground during the day, whence they soar away, like their progenitors of the preceding year, to propagate and destroy. When they greatly increase in any one locality, the parasites which feed upon them increase in a like

Digitized by Google

or even greater ratio, and soon diminish the progeny to a safe limit again, and for the next few years they are not likely to do much harm, while some section not before, or at the time infested by them, becomes their field of destructive operation until their enemies there destroy them, and thus they alternately attack and leave unmolested different regions at different times, and those places not yet visited by it are more liable to destructive attacks in the few coming years than those where the scourge has already prevailed greatly, and where it must soon fall a victim to its natural and inveterate enemies.

If the blighted appearance of a wheat field caused by the cecidomyia, were caused, as is supposed, by the weather, then there would be no remedy, and no means of predicting a failure of the crops; but such failure may be foretold by observing the numbers of the insects engaged in depositing their eggs, or a little later by examining the wheat heads to ascertain the prevalence of the larvæ. To do this, take a few heads of wheat at random, from a field, count the number of sound and affected grains, and the average of the crop may be easily calculated. The loss in some departments of France amounted in some years to one-eighth, then one-seventh, then one-half of the entire crop, particularly in early sown wheat, which the cecidomyia attacked and destroyed, and were then powerless to do further harm to late flowering wheat, as the eggs being once deposited they are done with their labor preliminary to the damage they cause.

Parasites of the Cecidomyia.—Simultaneously with the appearance of the yellow insect called *midge*, appears another quite different, being easily distinguished from it, although of nearly the same size, by being entirely black, having four colored legs, and being seen during the entire day. This insect is not, as has been thought, an enemy, but is a protector of the wheat-field, being the natural enemy of the cecidomyia, upon the progeny of which its young are fed, and without which our fields would soon cease to yield us a crop of wheat at all. It accomplishes its work of destroying the eggs of the cecidomyia by thrusting its long lance-shaped ovipositor through the glumes of the grain, and depositing its eggs within those of the midge; both insects being often found accomplishing their distinct missions at the same time upon the same ear of wheat; and although the destruction of the larvæ of the cecidomyia does not save the wheat crop of the current year, as these larvæ reach a development at the expense of the sap destined for the grain, yet they then perish, while the larvæ of the parasite living upon them give origin to an insect in their stead not injurious to succeeding crops. If, then, the cecidomyia be abundant and the parasites few in number one year, the next crop will be very meager, but if the para-

Digitized by Google

sites be very numerous, then the cecidomyia will be nearly exterminated, and seek a new section where it may prevail, as it usually does in one place, for two or three years, and then fall again before the increasing numerical strength of its deadly enemy.*

Means of Destroying the Cecidomyia, or providing against its ravages.—The parasite mentioned we regard as the greatest destructor of the midge, besides which there are at least two others less common, and there is another auxiliary found in a small spider who spreads his net for the midge near the roots of the wheat stalk. But we should not depend upon these means alone to cure the evil where its exists, or prevent its invasion of new territory. The ravages of the insect are very unequally great in different years; and this is owing, doubtless, to some definite cause or set of causes, which we should endeavor to learn, and which we might, perhaps, modify to our great advantage. And all the habits and transformations of the insect and attending circumstances being carefully noted may lead us to a knowledge of these causes.

When the eggs are deposited in the glume we can do nothing for the present harvest, but a preventive of future evil may be learned perhaps, from entomologists. When the larvæ reach the ground they penetrate only to a short depth, and changing into a chrysalis state lie there during the winter, unharmed by the frosts; but a deep plowing would turn them so far under that they would mostly perish, and then the wheat crop might be drilled in so shallow as not to turn them up again. Again, entomologists know that a hot sun and dry atmosphere are fatal to chrysalides, and a repeated light harrowing of the ground which contains these larvæ would expose vast numbers of them to this cause of destruction. Mineral manures might also be found very efficacious as a means of their destruction. Mr. Paul Theward, of France, has succeeded in destroying the Eumople or vine-hopper by an application of oil cake, of colza and rape-seed powdered, we believe, and prepared in a particular manner, but not heated in its preparation above 212° of Fahrenheit. Would not this prove an efficacious remedy for the *midge?*

---

* Dr. Asa Fitch, State Entomologist of the State of New York, is of the opinion that this parasite (*Platygaster punctiger*) has not yet reached America.

I have failed to find them myself, but have reason to believe that they are in Ohio. This belief is based upon the following ascertained facts: In a circular of queries, issued from this office, soliciting statistical and other agricultural information, addressed to County Agricultural Societies, was the following question:

"*Does the midge appear to increase in numbers for three or four years, and then suddenly disappear?*" To which forty counties answered in the affirmative. In the same circular was the question, "*What is color of, and how many wings has the insect which you call the midge?*" Several counties replied "*color*, black—*wings*, four—two large and two small." Several replied, "steel blue wings."

Digitized by Google

Burning the stubble fields destroys vast numbers of the larvæ. Would not lime, oil-cake as mentioned above, or other substances which would act in the double capacity of a manure and a poison to the insect be found beneficial, if applied at the time they emerge from the ground,—which, as is well known, takes place about the middle of June,—by destroying them before they deposited any of their eggs.

As the cecidomyia is ephemeral in its nature, being developed to the perfect state only to deposit its eggs and die, one means of preventing its ravages is to hasten the growth of wheat so as to pass the stage of growth at which the midge attacks it, and it then becomes a harmless insect. Another means recommended in France is to fish for them with fly nets, such as used by entomologists in making their collections; and vast numbers might thus be caught and destroyed. Evening is the time for a successful application of this means. Being nocturnal in their habits they might be attracted like other nocturnal insects, and thousands of them be destroyed by torches carried through the fields. Lime sprinkled upon the wheat just as the heads were emerging from their sheaths,* and fumigations by means of fires around the fields, impregnated with materials to produce an offensive and dense smoke have been tried with some success. Frequent changes of the time of seeding may be found very advantageous, as by this means the ravages of cecidomyia may be measurably prevented, by bringing the flowering time of the grain to a season too early, or too late for the midge. Each locality must regulate this change of seed-time according to the season of the attack by the midge in such district, which season should be carefully ascertained, and then late or early sowing, or sowing late or early ripening wheat, will anticipate or retard the cecidomyia and prevent its successful attack.

There are some important considerations as to the time when the cecidomyia should be destroyed, whether as a perfect insect, larva, or pupa; and it appears reasonable, that when the parasites of the midge are abundant, the larvæ should not be destroyed, as the vast majority destroyed really contain the larvæ of its worst enemy and the agriculturist's best auxiliary. So that destroying the larva does more harm than good. But if the parasite has not yet increased to such a number as to make their preservation a matter of importance, then destroy the larvæ as thoroughly as possible. This remark applies also to caterpillars, and other noxious insects.

Omitting the culture of wheat throughout an infected district for one

* This has been practiced in several instances which have come to my knowledge, but I believe in every instance the man that sprinkled the lime died from the effects of it.

Digitized by Google

or two years, and cultivating instead some other crop, is a safe and certain remedy, and one which, in case of necessity, may, and, in all probability, must be practiced. Variety of wheat has but little directly to do with prevention, as all varieties are subject to attacks by this insect; but a change from late to early varieties may, as already mentioned, be found sometimes advantageous.

History of the Cecidomyia.—We have only room to glance at the history of this important insect, which has not been satisfactorily described and classified by naturalists until at a comparative recent date. In France, until within a few years, it has been but rarely observed, although known in Germany, Switzerland, etc., somewhat earlier. But in these countries it has become only too well known since 1846. In England it was known and described as early as 1771, by Gallet, as one of the worst enemies of the wheat field. In that country its ravages were estimated at a loss equal to $100,000 in certain counties in 1827; $150,000 in 1828; and $180,000 in 1829; and Scotland and Ireland were not exempt from it. It was observed in the United States in 1820, and in 1828, 1829, and in 1832, it attracted particular attention by its terrible ravages. In the State of Maine alone it has caused a loss of a million of dollars in a single year; and wherever it has prevailed its destructive powers are almost beyond calculation; there are but few sections in the Union where wheat is cultivated which have not been visited by it, in greater or less numbers.

Authors differ somewhat concerning the habits of this insect, the number of larvæ deposited in a single grain or upon a single head, etc.; but this is because observations have not been equally carefully conducted, or perhaps so long continued by some as by others. Some suppose the larvæ to wait until a damp season to reach the ground by crawling down the stalk; others have observed its skipper-like action; and these rightly conclude that it is not the state of the weather but the stage of development which determines their descent. Some lay great stress upon the destruction of the sweepings of barn floors to destroy the larvæ, as they suppose that they continue in the wheat until threshed. This measure is certainly proper when many larvæ are thus found, but they do not thus remain in the wheat, other than as exceptions to the rule, because as a general thing they descend about the time the harvest is ripe, as already mentioned. Asa Fitch says they deposit from six to ten eggs upon a single grain, and sometimes attack other graminæ besides wheat; but the French authorities we have consulted do not record such an observation, although they agree with him as to the number of eggs.

The name of the insect is a matter of importance, as by establishing

Digitized by Google

one name definitely in its entomological description, confusion will be avoided. *Cecidomyia tritici* seems to be a fitting appellation.

The female *Cecidomyia* is about two millimetres long. Eyes black, occupying more than two-thirds of the head, separated by a yellowish line; thorax and abdomen of a lemon yellow, sometimes orange. The abdomen is terminated by a tractile ovipositor as long as the body, not visible in the ordinary state of the insect (Fig. 50). Claws long, yellowish. Antennæ composed of elongated joints, strung together like beads, upon a very fine connecting filament. These joints are flattened and somewhat hour-glass shaped, twelve in number, without counting the joint of attachment, these first being the longest, as though composed of two soldered together; they are armed with long hairs. The wings are transparent and ciliated, particularly at the borders. Figs. 50 and 55 give a good representation of their appearance. A question of importance, in the description of this insect, yet undetermined, is whether there be a little transverse nervure, besides the longitudinal ones, connecting the post-costal nervure to the side? This question is important, because upon its answer may depend a distinction of varieties, or species, and hence differences of habit and mode of prevention, etc., etc. M. Bazin, a French authority consulted by us, is of opinion that, in his country, such transverse nervure exists, and is best marked in the male (Fig. 55).

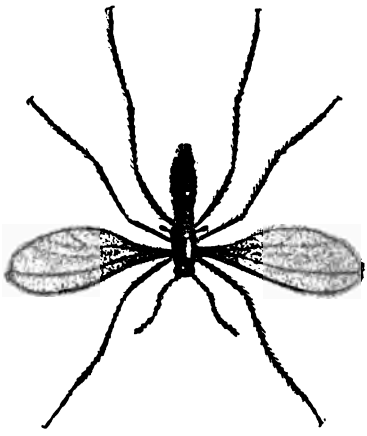


FIG. 55.
MALE CECIDOMYIA, MAGNIFIED.

The male *cecidomyia* is more rare than the female, and is distinguished by a shorter body, absence of the ovipositor, and less intense color. The thorax and abdomen are yellow-brown; wings slightly tinged with black, and have the nervures more distinctly visible. The antennæ differ; the joints are less elongated, spheroidal, thirteen in number, the first one in the female seeming to be made up of two joined into one. In the description of the male there are also differences among authorities, for the reason before stated, and further observations are required to make the characteristics of this insect well known.

Parasites of the Cecidomyia Tritici.—We have said that several kinds

Digitized by Google

of parasites attack the Cecidomyia tritici. One of them found as entirely in an exceptional state, is the *Macroglenes penetrans*. As to the other two Hymenoptera, we are under obligation for their determination, to the extreme politeness of Dr. Sichel, president of the Entomological Society of France, distinguished alike as an entomologist and as a physician.

Note of Dr. Sichel upon the Hymenopterous Parasites of the Cecidomyia tritici, arranged by M. C. Bazin.

The small hymenopterous parasites of the Cecidomyia tritici, both belong to the family of *Oxyures* of Latreille, or the *Proctotrupides* of Stephens and of M. Westwood, sub-family of the *Platygasterides*, of M. Westwood, genus *Platygaster* of Latreille.

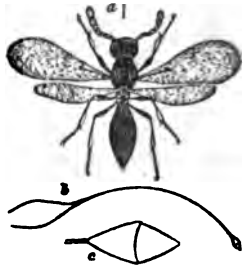


FIG. 56.
THE PLATYGASTER PUNCTIGER.
a Natural size.
b The ovipositor highly magnified.
c The extreme end of the ovipositor magnified.

The first of these little insects, that which M. Bazin has found so numerous that he regards them as existing in myriads, is the *Platygaster punctiger*, Fig. 56. Nees d'Esenbeck (Hymenopt, Ichneumonibus, affin, II., p. 307, No. 15). It belongs, at present, to the genus *Inostemma* of M. Walker, a genus which is distinguished by the submarginal nerve terminated at its extremity by a little disk, a character perfectly expressed (Fig. 56). This figure is, in general, conformed to the insect which I have placed under the microscope, and to the description given of it by M. Nees.

M. Nees assigns very hesitatingly six articulations to the antennæ, but examination under the microscope, leaves no doubt upon this point. After the scape, very long and somewhat large at its extremity, comes a pedicel, short and somewhat large, then four very small joints, and then four other very large, which form the club; but in the individuals which are very old and dry, which I have under my eyes, the limits of the joints are more frequently indistinct, and recognizable only by a very strong enlargement, which explains to me the hesitation of M. Nees. M. Fœrster, according to a letter communicated by M. Bazin, has made of this species the type of a new genus, which he calls *Isostazius;* as he does not indicate the essential characters of this genus, and as I have not at present at my command any other species of the genus *Inostemma*, I can not decide as to the correctness of this new generic distinction.

Digitized by Google

The second of these little hymenoptera is the *Platygaster scutellaris*, Nees. Although M. Bazin has only transmitted to me three individuals, very dry, which I have not had time to soften and stretch out, they suffice perfectly to display the specific characters: reddish or russet feet, antennæ almost entirely russet, having a club somewhat perfoliated of four joints, like Fig. 57, the shield, or corrica prolonged into a long spine, very broad at its base, and very pointed at its posterior extremity. The three individuals which I have under observation appear to be females, but I can not pronounce with certainty in reference to this. I intend examining anew, with more exactness, these two parasites, during the coming summer, when M. Bazin shall have furnished me more recent and numerous individuals.

FIG. 57.

As regards the insects which are represented in Figs. 56 and 57, and of which there has been transmitted me an abdomen, dried and deprived of legs and wings, and partly covered by a viscid matter, I have postponed an examination of it until I shall have fresh and entire individuals. It is the abdomen of the *Platygaster inserans* of Mr. Curtis, according to the drawing of that author, that is of the female *Inostemma punctiger* of Nees; for M. M. Bazin and Miqueaux, found it, before the mutilation of the individual, conformed to Fig. 56. It has been impossible for me to resolve this question myself, hitherto, as I neither have fresh individuals of the female of this insect having the sting protruding, nor yet the work of Mr. Curtis.

SICHEL, M. D.

PARIS, April 20, 1856.

CECIDOMYIA DESTRUCTOR, OR THE HESSIAN FLY.

When so much has been ably and carefully written in reference to the Hessian fly, all that can be done is to collect and arrange the separate items of information upon this interesting topic, as nothing new has recently been discovered in regard to it, and we can only hope to present the present state of knowledge in a clear and comprehensive manner.

The Hessian fly seems to have been an immigrant into this country from Europe, where it was known and described long before it commenced its ravages on this side of the Atlantic, where it first made its appearance in the year 1776, and is supposed to have been brought over in the straw used by the Hessian allies of the British troops, hence its common name in this country. At all events it was first noticed in

Digitized by Google

Long Island 82 years ago, and traveled inland at the rate of twenty miles annually, until it is now known as far west as Iowa and Minnesota, where wheat is cultivated.

From the most reliable information we are able to obtain, the Hessian fly makes an attack upon particular districts, some of them very remote, and, after continuing its ravages for two or three years, it disappears in that district for a number of years, and then re-appears; but it has rarely, if ever, attacked simultaneously the whole country in any one season, and there have been but comparatively few years in which it has not been injuriously abundant in some section or other of the United States. Wherever it has been very destructive, late sowing has seemed to have a great tendency to restrain and prevent its increase.

The insect, after having been called by various appellations, has at last received generally, the popular name of *Hessian Fly*, or *The Fly*, and its now well established scientific designation of Cecidomyia destructor; and has been very frequently described by different authors with sufficient accuracy to make it recognizable by almost any of these descriptions, among which, that by the late Dr. Harris, is perhaps as accurate and reliable as any, while the following abstract of the description by Dr. Asa Fitch, of the male and female fly is so authentic that we can not do better than give this as the standard of the descriptions of the *Cecidomyia destructor*.

The head and thorax of female, Fig. 58, (2)–(2), magnified and natural size, are black. The antennæ are about half as long as the body, and composed of sixteen joints, each of a cylindric oval form, the length being about double the diameter; each joint is clothed with a number of hairs, surrounding it in a whorl. The joints are separated from each other by very short translucent filaments, having a diameter about one third as great as the joints themselves. The thorax is oval and black; the poisers are dusky; the abdomen is of a dark color above, more or less widely marked at the sutures (joints) with tawny, fulvous lines, and furnished with numerous fine blackish hairs. The ovipositor is rose-red. The wings are slightly dusky. The legs are pallid brown, the tarsi black. The several pairs of legs equal each other in length, being about one-fifth of an inch long when extended; of which length, the tarsus embraces one-half. Short basal joint indistinct.

The *male*, Fig. 58, (1)–(1), natural size and magnified. The antennæ are three-fourths the length of the body. The abdomen consists of seven joints besides the terminal one, which consists of a transversely oval joint, giving off two robust processes, armed with incurved hooks at the tips. In the living specimen the abdomen is of a brownish-black color, more or less widely marked at the sutures with pallid fulvous or

Digitized by Google

smoky whitish lines. In all other points the male coincides with the female in its character.

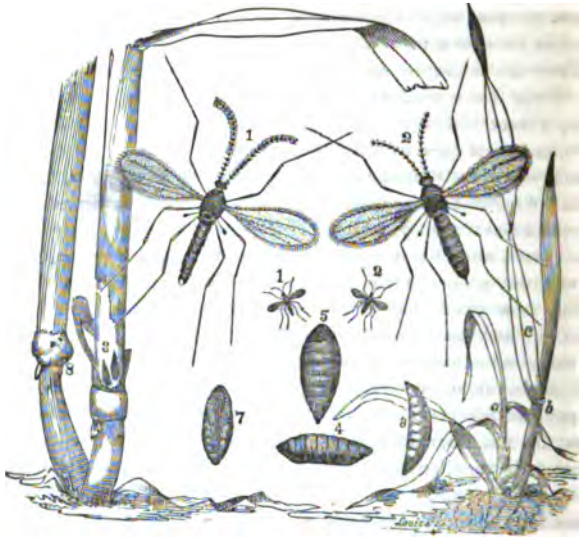


FIG. 58.

Fig. 58. *Cecidomyia Destructor* (Hessian Fly). 1. C. destructor (male) natural size and magnified. 2. C. destructor (female) natural size and magnified. 3. larvæ in flax "seed" state. 4. dorsal view of the larvæ magnified. 5. ventral view of the larvæ magnified. 6. lateral view of the larvæ magnified. 7. pupa. 8. Base of leaf sheath swollen from worms having lain under it and perforated by parasites coming from these worms. 9. Place where the larvæ are found in autumn. *a*. stalk of wheat attacked by the fly. *b*. *c*. healthy wheat plant.

The female deposits her eggs upon the young wheat leaves in September and May, between the minute ridges of the blade. They appear as minute reddish spots, and are cylindrical in shape, being about one-fiftieth of an inch in length, and one-two-hundred and fiftieth in width.

The eggs laid in the autumn hatch in a week, if the weather be warm, or two or three weeks if cold and unfavorable, and produce white maggots, which pass down the leaf, between the sheath and stem, until it reaches the first joint or crown, and remains fixed upon the stem, head downward, Fig. 58, 3, until it assumes the pupa form.

The young fall wheat attacked by these maggots, withers next spring, while others proceeding from the same root will remain unaffected, and

Digitized by Google

this death is caused by the nutritious juice being abstracted from the shoot. The spring-hatched maggots attach themselves to the second or third joint of the plant which is better able to resist their injurious influence. Fig. 58, *a*, represents a plant withering from the effect produced by these maggots, while the stalk *b*, a tiller from the same root, is unaffected; and hence wheat which tillers well is less liable to suffer extensively than varieties less disposed to this process.

The maggots seem to live by suction alone, as they do not penetrate the stalk, and the injury they cause to summer wheat seems to be by their pressure between the leaf and inclosed stem, preventing the circulation of sap, and the deposition of silica upon which the strength of the wheat straw and its ability to resist winds, etc., greatly depends. Sometimes a swelling or gall (Fig. 58—8), is produced by their presence. Those varieties of wheat which have a naturally strong tendency to the deposition of silica and the formation of a hard flinty stalk, have been found to resist the attacks of the fly best, and for the reason that they are better able to resist breaking by the winds. Moreover, tillering well, which is an indication of health and vigor in the plant, may compensate for the injurious effects of the presence of the maggot, when not in overwhelming numbers, and good tillage and careful selection of seed will do much to prevent detrimental attacks of the insect.

The fall-deposited egg hatches out a maggot which makes its way down the stem and is soon transformed into a dormant larva, surrounded by a case formed of the skin, which remains in the position marked at 8, Fig. 58, a stem from which the leaves have been stripped, during the winter, without undergoing any marked change. This pupa is seen magnified at 5, Fig. 58. A magnified dorsal view of the active worm or larva is given at 4, and a lateral view of the same at 6, Fig. 58. When spring arrives, the dormant larva becomes transformed into a pupa, or chrysalide, and after remaining in this position ten or twelve days, the pupa-case bursts and the perfect insect emerges, about the flowering-time of the early spring flowers.

The larvæ of the Hessian fly have by their capacity to pass into the dormant-larva condition a great power to resist extremes of temperature and atmospheric changes during the winter; how they resist, like other pupæ, the tendency to freeze during the intense cold of our northern winters is a mystery; but that they do so may be determined by examining the partially developed pupa which will be found flexible, as in the case with the pupæ of some other insects which have been found unfrozen, although the temperature had sunk to many degrees below the freezing point.

Digitized by Google

The progeny of the fall fly which have passed the winter in repose upon the stalks of the wheat, in the spring become developed into the perfect insect state, and then make a new deposit of eggs upon the same stalk which gave them lodgment during the winter, or the neighboring ones, but upon leaves a little higher up, as the radial leaves are now more or less withered. The worm hatches, makes its way to the base of the leaf of the first or second joint, where it does not so greatly injure the plant but that it may become well developed; but a slight swelling usually points out its place of rest. Commonly, however, the stalk bends or breaks, and gives a badly infected field an appearance as though a herd of cattle had run through it. The worm attains its growth about the first of June, becomes a pupa, and undergoes its transformation to the perfect state and emerges a complete fly during the last of July or first of August, to recommence its depredations upon the fall wheat.

The *Cecidomyia destructor* is subject to the attacks of numerous *parasites* which serve to moderate its multiplication very greatly. When the eggs are deposited upon the wheat leaves, they are visited by a minute four-winged insect, of the *Platygaster family*, elsewhere described, and punctured by it, and receives a deposit of from four to six eggs of this insect within each egg of the fly attacked, and with these within and feeding upon it, passes on to the dormant-larva state, when it dies, and these, its destroyers, at a proper season, escape from its empty shell. Three other minute insects attack it in the larva state, of these the most common is the *Ceraphon destructor* of Say, which, alighting upon a wheat stalk, instinctively sting through the stalk into the larvæ in their dormant state, deposit an egg which hatches to a maggot, which lives in and feeds upon the worm or the fly. The attacks of these and other foes of the Hessian fly are so destructive that probably not more than one-tenth of the eggs deposited by it ever arrive at maturity. The second generation of the fly, that is, those hatched in the summer, are seemingly most subject to the attacks of these parasites.

The means of preventing the ravages of the Hessian fly, which have been proposed and practiced, are very various, but none can ever be found probably, which will entirely destroy the insect, or wholly prevent its ravages, as the laws of equilibrium between vegetable and animal life, are such that they can not be set entirely aside, and we can only hope to restrain their attacks within comparatively harmless limits.

A *fertile soil*, rich in all the constituent elements necessary to a healthy growth of the wheat plant, is of the first importance This it lies within the power of the agriculturist to control by proper manuring, plowing to a proper depth, etc., and it is even supposed that the *Hessian*

Digitized by Google

fly has been a benefit by compelling farmers to adopt a better mode of culture than was formerly in vogue in some places, and still is in many sections, and this improved culture has had the effect not only of lessening the ravages of the fly, but of increasing the productiveness of the better cultivated lands.

Late sowing is one of the best and easiest remedies for the fly, as it perishes before late sown wheat has made its appearance, and to avoid those accidents and diseases incident to late sown wheat proper means have been pointed out in the appropriate place, as draining, manuring, littering, etc. *Grazing*, *rolling* and *mowing*, have been recommended as good remedies, either to remove or destroy the eggs and larvæ. *Fly-proof wheats*, that is, such varieties as tiller well and have a hard silicious stalk, have been recommended, and found to offer a good means of lessening the injurious attacks of the *fly*. For a description of varieties of wheat possessing these properties, see the list of the varieties and characteristics of the plant in the preceding pages of our article upon that subject.

Soaking seed wheat has been noticed in connection with other subjects, and may be referred to here. Various materials have been used in solution, to hasten the germination of wheat, particularly when sown late, and some of the materials acting as manures give the wheat greater vigor and strength to resist the effects of the *fly*. Hot *salt water* (not hot enough to kill the germ in the grain), applied to wheat upon which a mixture of charcoal dust, guano, sulphate of ammonia, and other ingredients was used by a Mr. Pell, of New York, with a seemingly good effect upon the productiveness of the crop.

Oats as a decoy has been sown, and then, after the fly had deposited its eggs, the oats were plowed in, but this is equivalent only to late sowing.

Decoy wheat patches have been sown in the middle of fields, and the flies being attracted to these, have deposited their eggs before the later sown portions of the field had grown up, and were then plowed under, but this is not a very efficient remedy in years bad on account of the great numbers of the flies.

Deep covering is not good, as will be seen by referring to where this subject is mentioned, *late shallow sowing* being equal as a remedy, and far superior for promoting the growth of the plant.

Procuring seed from uninfected districts is useless. *Sun drying* is equivalent to *late sowing*. *Sprinkling with salt lime* and other supposed remedial agents amounts to manuring only.

Burning and plowing up the stubble are good local remedies, if per-

Digitized by Google

formed immediately after harvest, but to be of the greatest utility should be practised in most, or all, of the infected district simultaneously. But if a wheat stubble field be twice plowed, the second plowing brings up the eggs, and many of them batch out, and the fly is not destroyed.

Late sowed wheat is liable to the midge, rust, and smut, and to avoid all these contingencies at once, late sowed wheat should be properly stimulated to rapid germination and vigorous growth by proper soaking, shallow covering and good manuring, deep plowing, and a selection of an early ripening kind. These, with the other means pointed out, will in all ordinary years be sufficient to guard the wheat from the attacks of this one of its worst enemies.

Why this insect and many others should be more abundant some years than others, it is at present impossible to determine with certainty; but one thing is well established, that a constant and wide-spread cultivation of its favorite food, the wheat, insures it the means of subsistence, and favors its propagation so greatly that its eradication can hardly be conceived to be within the bounds of possibility, and the unknown conditions upon which depend its extraordinary multiplication in particular years, may always be so far looked for as likely to occur, as to stimulate the farmer to a constant care both as to the manner of cultivating wheat and to a rational and suitable rotation of crops, to avoid, as far as possible, any sudden increase of this pest from affecting his interests seriously. And the intelligent agriculturist will seldom suffer serious loss if he apply his knowledge to a practical use.

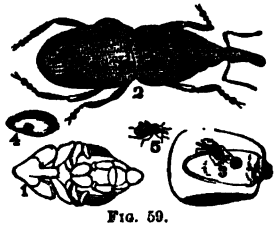


Fig. 59.

Fig. 59. Calandra granaria or Granary weevil.

1. Pupa.
2. Perfect insect magnified.
3. Insect emerging from grain of corn.
4. Grain of wheat from which the insect has escaped.
5. Natural size.

Calandra granaria (*granary Weevil*) one of the most destructive insects which live among stored corn and wheat. About April, or as soon as the weather is warm enough, the beetles pair, after which the female burrows into the corn heaps, and pierces a minute hole with her beak in a grain, Fig. 59, 3 or 4, laying an egg in each, until they are all deposited, which often is not until the approach of autumn. The maggots soon hatch, and feed upon the flour until the husk alone is left; each grain supplying sufficient nourishment to bring its inhabitants to maturity, when it changes to a pupa: Fig. 59 (1), and in about six or seven

Digitized by Google

weeks from the time of pairing, the perfect weevil is hatched, and eats its way out of the grain.

Unless the weevils are seen walking over the corn, it is difficult to detect their presence until they have been at work some time, and the holes of their exit become visible in the empty grains, Fig. 59 (4). On throwing a handful, however, upon water, their operations are manifested by the floating kernels. The grain weevils can not endure cold, being natives of more southern regions; and, consequently they desert the grain heaps on the approach of winter to seek a warmer abode in the chinks of walls and crevices in beams or floors, etc., so that if the old stock of grain be then removed, unless the weevils be ejected or destroyed, they are ready in the spring to commence upon fresh samples of any sort of grain, although they give preference to barley and malt. Corn, however, sometimes suffers greatly from their inroads, as well as wheat and oats.

Of course the eggs are extremely minute; the maggots have no feet, are white and fat, with horny ochreous heads, armed with little jaws; the pupa is of a transparent white, disclosing the members of the future weevil through its clear skin.

The beetle is one of the Curculionidæ, and is appropriately named *Calandra granaria*. It is nearly two lines long, Fig. 59 5), magnified at (2) smooth, shining, a little depressed, and varies from a dark chestnut to a pitchy color; the head is furnished with two small black eyes, and narrowed before into a proboscis, which is shortest and thickest in the male; at the apex are placed the jaws and mouth, and before the eyes it is a little dilated, where the slender elbowed horns are attached; these are nine-jointed, and terminated by a little ovate club; the thorax is large and narrowed before to receive the head; it is coarsely and thinly sprinkled with oval pits; the wing-cases are short and oval, with eighteen deep and punctured furrows down the back; it has no wings; the six legs are short and stout; the shanks are hooked at their extremities; the feet are bent back in repose, being four-jointed, the third joint heart-shaped, fourth furnished with two claws.

C. Oryzæ, the rice weevil, is another species not less destructive abroad, especially to the rice of the East Indies, to wheat in the southern States of Europe, and to the corn of Guinea. Fortunately, our climate is too cold for them, so that it is doubtful if they breed in Ohio, although the beetles are no uncommon inhabitants of rice, etc. Its transformations are similar to those of *C. granaria*, but the weevils are rather shorter and not so smooth, they vary from an ochreous or golden color to chestnut or pitchy, according to the age; the eyes are black; the thorax is rough, with strong crowded punctures, the wing-cases are

Digitized by Google

broadest at the base, with rows of punctures down the back, forming ridges; in the dark specimens, four large paler spots are very visible on the back, two at the base, and two toward the tail. It has a pair of ample wings folded beneath; the legs vary but little from the foregoing species.

Meraporus Graminicola (or an allied species of *Chalcididæ*) is parasitic on the larvæ of the rice weevil, *Calandra oryzæ*. It is only two thirds of a line long, and like a minute ant, but of a glossy blue-black color; head hemispheric, with an eye on each side, and two short horns in front; thorax oval; abdomen elongate conic; wings none or rudimentary; six legs, stoutish and ochreous, with brown thighs.

No better remedy for the weevil is practicable than to omit storing grain in the granaries infested by them, for one or two years, until these insects have perished or emigrated. Perhaps fumigation with burning sulphur might, where practicable, be found a good remedy.

Chlorops is a genus of insects which reduces the value of corn crops to a great amount by depositing eggs in the young wheat, barley and rye. These eggs produce maggots, which either eat through the base of the central stalk, destroying the ear, or by working up the straw, Fig. 60, the ear is rendered more or less abortive. There are several species which are engaged in these operations.

C. Lineata (the striped wheat-fly) lays its first brood of eggs in June, when the ears are just appearing; they are placed at the lower part of the ear, at the bottom of the sheath; they hatch in about fifteen days, when the maggots pierce the tender straw, and make a narrow channel on the same, up the ear, Fig. 60 (6)–(11)–(12), it there changes to a brown pupa, Fig. 60 (12), toward the middle of the furrow, and the flies hatch in September, laying their second batch of eggs upon the rye and other corn, recently sown. The fly is yellow; horns, and a triangle on the crown, black; thorax with five black stripes; abdomen with dusky bands, and a dot on each side at the base; apex yellow; legs yellow; anterior feet black, the others yellow; with the two terminal joints black; length one and a half lines.

C. Tæniopus (the ribbon-footed corn-fly), Fig. 60 (2), magnified at (3), is the species which does the greatest mischief in England, causing the disease in wheat and barley called the gout, from the swelling of the joints. The fly is pale yellow; horns black, and a black triangle on the crown; thorax with three broad black stripes, and a slender black stripe on each side, also a black dot on the side of the breast; abdomen pale greenish black, forming four black bands and two dots at the base;

Digitized by Google

wings transparent; poisers white; legs ochreous, basal, and two terminal joints of forefeet black; the others, with the two apical joints only black; length one and a half line.

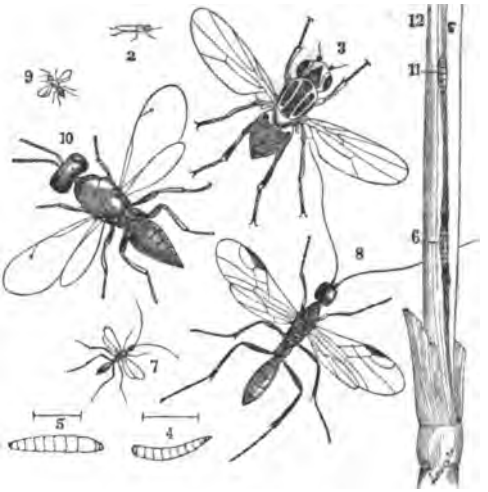


FIG. 61.

Fig. 61. 1. Chlorops tæniopus, or ribbon footed wheat fly. 2. natural size. 3. same magnified. 4. larva or maggot of same. 5. pupa of same. 6. one of the pupæ fixed in the stalk. 7. Cœlinus niger (natural size). 8. Cœlinus niger, magnified. 9. Pteromalus micans (natural size). 10. Pteromalus micans, magnified. 11. larva of Chlorops containing the larvæ of Cœlinus niger. 12. point of escape of C. niger from the indurated skin of No. 6.

These flies also deposit their eggs between the leaves in the autumn, and in spring, when the maggots live in the base of the stem; and, of course, destroy the shoot, or render the ears unproductive—the wheat sometimes altogether failing; in other instances, one side only of the ear, with the greater portion of the grain, becomes shriveled. The maggots, Fig. 61 (4), are whitish, shining, tapering to the head, blunt and tubercled behind; the elliptical pupæ (5) are of a rusty color and fixed in the groove of the stalk (6) or inside of the closed leaves; from which the flies crawl forth with their crumpled wings in August, and are found in stacks through the winter.

Asa Fitch, who has devoted much attention to the study and description of noxious insects, has described, among others, the species of Chlorops peculiar to the country of North America, and particularly to the portion embraced by New York and the adjacent States, with Canada.

Digitized by Google

FIG. 62.
Wheat Mow Fly, natural size 1-12 of an inch in length.

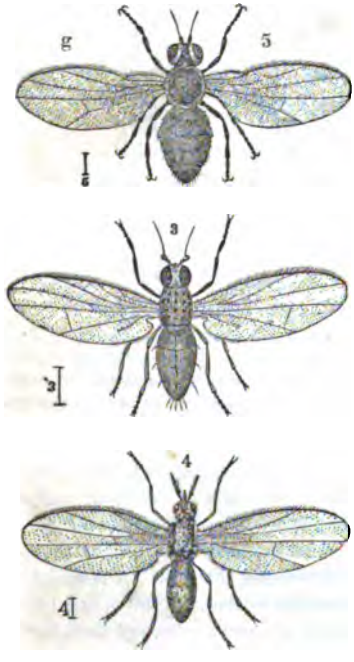


FIG. 63.

g. Wheat flies.
3. Deceptive wheat fly, natural size and magnified.
4. Comm n wheat fly, natural size and magnified.
5. Shank banded wheat fly, natural size and magnified.

These are sufficiently like their relatives already described to render an extended notice of them unnecessary. They are all more or less destructive to the wheat plant, and thus force themselves upon the attention of agriculturists, and will ultimately meet with such a careful examination by this class of citizens as to be far better known than they are at present. Figs. 62, 63, are magnified views of the American varieties of the Chlorops, and do not require to be more carefully described, as the European species described and figured in this article are so like them, that, except for the purposes of nice entomological distinction, a description of the form and habits of one might serve as a basis of acquaintance with the other.

There is a parasite named *Cœlinus niger*, Fig. 61 (7), magnified at (8), which punctures the maggots; and these again fall victims to the beautiful little Pteromalus micans (9), magnified at (10).

Cœlinus niger is a small ichneumon fly, parasitic upon Chlorops (Fig. 61). The eggs are supposed to be laid in the maggots, in the stem and spathes of the green wheat, feeding upon the former as soon as they hatch, and undergoing their transformation in the indurated skin of the Chlorops maggot (11). The Cœlinus hatches several days before the Chlorops, and eats a hole through

Digitized by Google

the leaves to escape (12). There are twelve British species, which are abundant from Midsummer to Michælmas, in meadows; the one bred from the wheat Chlorops is named *Cœlinus niger* (7), magnified at (8), being of a pitchy color; the two long-jointed horns, head, and trunk, are glossy black; the abdomen is narrowed at the base; the ovipositor of the female is scarcely visible; the four wings are transparent; stigma brown; legs slender; four pair ochreous, with dusky feet.

Cucujus Festaceus.—This minute corn beetle inhabits granaries and mills, eating into the wheat, and depositing its eggs, which produce little ochreous larvæ, with forked tails, Fig. 64 (1), magnified at (2), that feed upon the farina, and, with the weevils, do great mischief. In all probability they undergo their transformation in the grain.

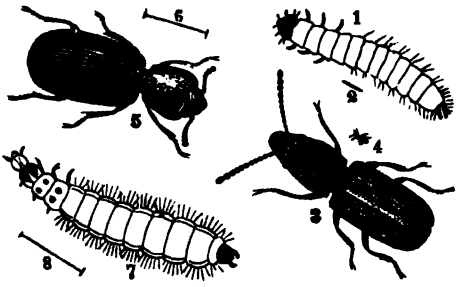


FIG. 64.

The beetle (4), magnified at (3), is depressed, and bright fulvous, finely punctured, and clothed with short ochreous down; the head is large, with two little black eyes, and two straight eleven-jointed horns; the thorax is squarish, the wing-cases of six indistinct ridges, and conceal a pair of ample wings; it has six small legs. Fig. 64 (5) and (7) are Trugosita mauritanica (see p. 628), and its larvæ, which also injure grain.

Micropus Leucopterus (Say), the chinch bug (Fig. 65 natural size and greatly magnified), is undoubtedly one of the most pernicious insects, according to the writings of Asa Fitch, which we have in the United States. Although not confined to the southern portion of this country, its destructive habits have been most severely felt in that section. It is a small insect, of coal-black color, with snow-white wing-covers, which are laid flat upon its back.

They made their appearance in North Carolina in 1783, and by 1785 had become so numerous and destructive as to cause the culture of wheat to be abandoned in some districts for four or five years, and again became destructive in the same State in 1809, and probably at other times. In the *Cultivator*, Vol. VI., p. 103, A. D., 1839, W. S Gibbes, of Chester, S. C., describes their ravages in the wheat, oats and cornfields, as exceedingly destructive, and was compelled to burn them, corn and all, to save

Digitized by Google

the parts of fields which had not yet been attacked. The season he describes as hot and dry.

Fig. 65.
Upper fig. natural size.
Lower fig. magnified.

J. W. Jeffries, of North Carolina, describes their attacks upon the wheat fields as beginning late in May and early in June, and as the wheat ripens or is destroyed by them, they migrate to other fields, oats, corn, etc., and then to the woods, in incalculable numbers. The rapidity of their multiplication is great beyond estimation.

In 1840, the total destruction of the wheat crop was threatened, but the season became wet, and the insects were destroyed, and their ravages were arrested. About this time (1840–4), they became known on the upper Mississippi by the name of "Mormon lice," as the Illinois people supposed that the Mormons were the causers of this pest, as our ancestors supposed that the Hessian fly was bred by the German allies of the British troops. It was described by Dr. Le Baron, as a most formidable scourge, devastating the fields of wheat and other crops, and emiting a smell living or dead, which is most disgusting. In this section of country many fields were burnt over to prevent spreading and to avoid their return another year. It was noticed to be most abundant in the south and east parts of fields, but in swampy places, the wheat or other grain was untouched. It was but little noticed in wet seasons, but three consecutive dry summers (1855), served to multiply it prodigiously. Early wheat escaped its ravages, as did the first crop upon newly broken-up prairies. The grain from injured fields is light and shriveled, when compared with other samples.

Various writers of the West, mention or describe this insect from 1850 to 1856, and all concur that, when numerous, it is very destructive, that it first attacks the wheat fields, marching forward in the work of destruction, with pretty well defined lines like an army, once in a while sending out a small foraging party to destroy a small patch of wheat or other grain, beside the main line of devastation. When the wheat has been killed or cut, when it has become sapless, they march to other fields, oats and corn, which latter they are said to cover so closely some-

Digitized by Google

times, as to make the stalks look as though painted black. Wherever they go in numbers the grain dies.

These insects belong to the Hemipterous genus Rhyparochromus, family hygæidæ. Length 1¾ lines, or 8-20 of an inch. Body black, covered by a fine gray down, not visible to the naked eye; basal joint of the antennæ honey-yellow, second joint the same, tipt with black, third and fourth joints black, head brown; wings and wing-cases white; the latter black at their insertion, and have near the middle two short irregular black lines, and a conspicuous black marginal spot; legs dark honey-yellow, terminal joint of the feet and the claws black. The young individuals are vermilion red, thorax brown, with a white band across the middle of the body, comprising the two basal segments of the abdomen. As they increase in size they become darker, changing first to brown, and then to a dull black, the white band still remaining. The antennæ and legs are varied with reddish, and gradually change until they assume the characters of the perfect insect.

They are propagated by means of eggs, deposited in the ground, and are hatched out in the spring. They never appear, like insects of other orders, as maggots; yet in the larvæ, or developing state, they differ much from the perfect insect.

Dry seasons favor their production—wet kills them, hence the practical deduction that drenching fields infested by them, copiously, by means of a garden, or other watering engine, would afford a means of arresting their ravages; and this might be done in many situations, with so little labor and expense, that the grain saved from their rapacity would amply repay for the outlay of means. There is no other feasible means of destroying them known at present, but, doubtless, Providence has placed within the reach of human ingenuity, all the means needed for the preservation of man, and the works of his hands, and necessity will prompt their discovery sooner or later.

Miris erraticus, Linn., is abundant in wheat fields from the beginning of July till late in autumn; it is narrow, and three and a half lines long, of a straw color; the horns and legs more ochreous, long, and slender; the former black at the base and apex;

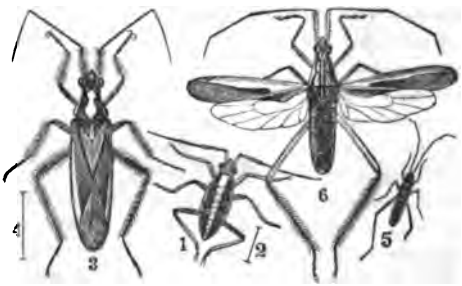


FIG. 66.

Digitized by Google

the thighs spotted with black, and there is a broad slate-colored stripe from the nose to the extremity of the wings when they are closed.

M. tritici, Kirby, is apparently only a pale variety of the foregoing. It is very common in wheat fields, from earing to harvest-time. Fig. 66 (5), shows the natural size at rest; (6) the insect flying.

Lepidotus, or Elater Holosericens (the Satincoated Click-beetle).—Nothing is known of the wire-worm which produces this elater; it is deep brown, variegated with shining ochreous rings and spots; the legs are rusty, and the wings ample. It is abundant in wheat fields, under stones, etc., from April to August. All the elaters have the power to leap up when laid on their backs, by employing in a special manner the head, the trunk, the base of the body or post-pectus, with four cavities in which the legs were inserted; the lobe being pressed into the cavity in the chest and under the edge, the head and trunk are thrown back, the lobe is suddenly liberated, and the animal is jerked up to regain its feet.

Noctua (*Agrotis*) *Tritici*, Linn. (the wheat full-body moth), expands from one and a quarter to one and a half inches; is ashy brown; superior wings, with an oval and ear-shaped pale spot on the disk, and a dark, elliptical one below; also two wavy lines beyond, and between them is a row of pointed black streaks; the pinion edge is spotted; inferior wings dusky, white at the base in the male; legs annulated with white. The caterpillar is naked and yellow, with three white lines, and feeds on the ears of wheat.

N. Agrotis Lineolati, Har., is probably a variety of N. tritici, which, from the myriads of moths that have occurred in Kent, just befor harvest, must greatly diminish the wheat crops in some seasons.

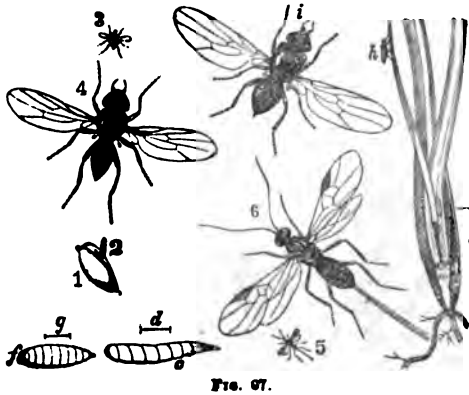


Fig. 67.

Oscinis is a genus of flies closely allied to chlorops, and similar in its economy —the larvæ being very destructive to wheat before it ears.

O. Granarius (Curt.) seems to differ from the other species, as, from the little that is known of it, the

Digitized by Google

larvæ are presumed to live in the ears of wheat, as musca or chlorops first does in those of the barley. Fig. 67 (1) represents a grain of wheat, with the shining ochreous pupa attached (2); the fly hatched from it expands only two lines; it is shining black, with a greenish cast; the horns are small; the head is rather large with two lateral eyes; the thorax is globose-quadrate; body conical; wings transparent, ample, similar to those of chlorops, but the dark, cortal nervure extends to the second apical one; club of balancers ochreous; four posterior legs black, basal joint of feet dull ochreous (3, 4, magnified).

O. Pumilionis (Bierk), the Rye-worm fly, is very destructive to that valuable crop in Sweden, stunting its growth, and causing the stems to die; the little white maggots inhabit the base of the stem, changing to yellow pupæ the end of May, and the flies hatch the middle of June. They are one line long, and yellow; eyes, horns, and a triangle on the nape black; thorax and body black above; the former with two yellow lines down the back; the poisers are white; legs grayish, black at the extremities; the fore legs bear two black spots.

O. Vastator (*Curt*).—The larvæ of this fly injure wheat crops to a great extent; they are found in the spring near to the base of the stem (b), and by eating through the plume (a) it can be drawn out; it therefore soon withers, and the future ear is destroyed; they are yellowish, tapering to the head, blunt at the tail; the mouth is furnished with two black, horny points (d, g, the natural length). About midsummer they change to elliptical rusty pupæ within the folds of the leaves (c, f, the same magnified; e, the natural length). The flies hatch early in July, and are very similar to O. granarius in size and color, being shining greenish black; the wings lie flat on the back in repose, and extend considerably beyond the body; all the nervures are pitchy; club of poisers ochreous; base and tips of four anterior shanks rusty, as well as the base of all the feet (3, natural size walking; 4, flying and magnified). As the plants sometimes tiller after being visited by these pests, pulling up and burning the plants is not always advisable. The best remedy is the alternation of green crops, which do not attract the oscinis, and on which their larvæ can not subsist: for probably nothing tends more to infect land with insect plagues, than successive cropping and slovenly farming. But one of the best and most efficient friends the farmer has, is the female of a little black fly (5), which, with its long ovipositor, pierces the infested stems and lays its eggs in those of the oscinis; the maggots of both hatch, one feeding inside of the other, without hindering its growth, until they are full fed and change to pupæ, still one within the other; but instead of the fly of the oscinis, that of the parasite comes forth to fulfill its mission—checking the multiplication of

Digitized by Google

the baneful oscinis. The parasite is named by Nees von Esenbeck, Sigalphus candatus; it is entirely black, excepting the transparent wings, with pitchy stigma and nervures; the fore legs are tawny, excepting the base of the thighs; base of the other shanks tawny; expanse of wings, 1¾ to 2½ lines (5)–(6) magnified.

Pachymerus Calcitrator (Grav.), is a parasitic ichneumon, which keeps in check Cephus pygmæus, whose larvæ feed in the stems of rye, wheat, and barley. This fly punctures the larvæ when they are concealed in the stem, and as soon as the eggs hatch, the parasitic maggots feed upon the others, change to pupæ in the straw, and the *ichneumon* is bred from them in June. *P. calistrator* expands half an inch; is shining black; head large; horns like two longish brown threads, yellow beneath; abdomen compressed, slender at the base; third and fourth joints reddish, remainder brown, edged with white; four wings ample; hinder legs long and brown; four anterior ochreous on the inside, hinder thighs thick, the shanks sometimes tawny. Female antennæ shorter; abdomen spindle-shaped, four first segments reddish; oviduct projecting.

Fig. 68.

Polydesmus Complanatus, Linn., (the flattened Milliped), is often the most destructive of all the species in the field and garden, eating in the spring the roots of grain and vegetables, especially wheat, carrots, beans, and onions; it varies from a quarter to a half an inch in length; is of a pale lilac color, linear, and flattened; it has no eyes; the two horns are short and clubbed; the body is composed of nearly twenty granulated segments, with the hinder angles acute, and the tail mucronate. It has between sixty and seventy legs, tapering, jointed, and of an ochreous tint, Fig. 1 and 2 magnified.

Proctotrupes Viator (Hal.), is a parasitic fly, which lays its eggs in wire-worms and other subterranean larvæ, thus being of great service to the agriculturist. It is black and shining, the horns and legs reddish, dusky at their tips, the former are slender and thirteen-jointed; the body is ovate conic, attached by a slender neck to the elongated thorax, and the tapering apex is furnished with a stout curved ovipositor; the four wings are transparent, almost nerveless, with a triangular brown spot on the costa of the superior: they expand about one quarter of an inch.

Digitized by Google

PLATYGASTER TIPULÆ.

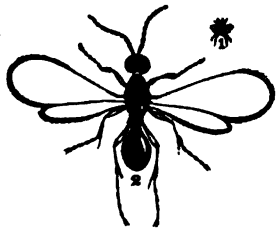


FIG. 69.

FIG. 69. 1, natural size, 2, magnified.

This minute insect belongs to *Proctotrupidæ*, and to it we are indebted for the destruction of myriads of the wheat midge. The female is of a shining black color; wings transparent; without nervures; antennæ ten jointed; bright ochreous; thighs and shanks clubbed; feet long, slender, and five-jointed. The tip of the abdomen is armed with a long curved ovipositor, with which it pierces the larvæ of the wheat-fly and deposits an egg, which speedily hatching becomes a small grub, that living upon the fatty matter of the midge larvæ, ends by destroying it.

Curtis, one of the best European entomologists, says of this insect: "This insect, of all others known, is the greatest enemy of the fly. It does not like strong sunlight, but takes shelter within the husk of the grain, and among the leaves. When about to deposit its eggs, it travels over the whole head with great rapidity, and bending its body, inserts the ovipositor, with a vibratory motion, into the larvæ of the fly. In a short time the deposited egg hatches, and the grub begins to feed upon its victim. By this means the immense increase of the fly is reduced, as the stung larvæ never become flies."

Pteromalus micans (Oliv.) is a brilliant parasitic fly, which hatches from the stems of wheat infested by the *Chlorops*, Fig. 61. These little creatures have the power of discovering the hidden larvæ and pupæ, in which the female, Fig. 61 (9, 10 magnified), lays her eggs, to live upon the fat and muscles of the *Chlorops*.

The sexes of *P. micans* are very dissimilar; the male is of a lovely green, with a blue or yellow tinge; the flail-shaped horns are brown and thirteen-jointed; the body is strap-shaped, black, smooth and shining; the wings are transparent, with a short curved nervure on the costa, legs bright ochre, thighs pitchy, feet tipped with black. The female is dull green; base of horns ochreous; the body is lune-shaped, violet above, metallic green at the base; expanse three lines.

P. Puparum (Linn.) is bred in multitudes from the pupæ of *Pontia Brassicæ*, and other white-cabbage butterflies. The sexes vary, and resemble *P. micans*. The male is brilliant green; horns, slender,

Digitized by Google

tawny; body very glossy and golden green; wings limpid; legs bright ochreous; tips of feet pitchy. Female greenish-black; horns black, ochreous at the base; body shining black, often violet above; base metallic green; legs bright ochre; thighs pitchy, excepting the base and tips; four hinder shanks brown in the middle; tips of feet black; expanse three lines.

Staphylinus is a genus of Rove-beetles, and a small larva, which is presumed to be the offspring of some one of the species (possibly a Tachyporus) has been detected injuring the wheat-crop, and destroying one-fifth of the plants.

This larva is scarcely one-fourth of an inch long; the head is furnished with strong jaws, feelers, and two little horns; it has six jointed legs, terminating in claws; down the back and sides of the body are four rows of spines, being four on each segment; the tail has a fleshy foot, and two feelers, composed of four joints, which are useful in burrowing. In October, these larvæ attack the green wheat, causing the death of the plants by cutting round the stem with their strong jaws, about an inch under ground; the object being to get at the white shoot, which they eat. At this early stage of the crop, the empty husks of the grain remain attached to the roots, and into these the larvæ retreat when disturbed, making them their habitations, and possibly cells also, to undergo their transformation in.

Staphylinus, or *Ocypus olens* (Fab.), the Fetic, Rove-beetle, is one of the largest and commonest species, and, from its ferocious appearance when irritated, it is usually known as the devil's coach-horse. It is however a most useful insect to the cultivator, for, in its larvæ state, it lives underground, feeding entirely upon animal substances during the winter; in the spring it is full fed, and forms a cell beneath a stone or clod to become a pupa. In September and October these beetles are abundant everywhere, and occasionally a few are around in the spring; but it is in the autumn they are most serviceable in destroying the ear-wigs upon which they live. S. olens is of a dead black, thickly punctured, and covered with short hairs; the head is large, with two powerful jaws; the horns are short; the wing-cases are small, quadrate, and cover two tawny wings, which are too short for flight; the body is long, and it has six strong legs (the figure was given to the engraver, but was not finished in time). See Fig. 859, Morton's Encyclopedia of Agriculture.

Tenebrio Molitor (Linn.), (the meal-worm beetle), generates in flour, bran, and meal bins, and is consequently found in granaries, mills, and farm-houses. The beetles appear in April, May, and June. They are

Digitized by Google

smooth, slightly depressed and of a pitchy, or chestnut color, especially the under side and legs; minutely and closely punctured; head somewhat orbicular, with two small eyes, and short, slender, even jointed horns; thorax sub-quadrate; hinder legs acute; elytra elliptical, with sixteen shallow furrows, and beneath them

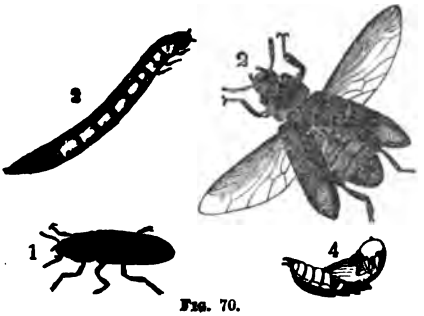


FIG. 70.

ample wings, which are smoky on the costa; legs stout; feet five-jointed, hinder pair with only four joints (Fig. 70 (1); flying and magnified at 2). The meal-worm is cylindric, smooth, ochreous, with bright, rusty bands, and a few scattered hairs; two small horns, six pectoral legs, and two minute spines at the tail (3). The pupa (4), is pale ochreous, with the members visible, and two spines at the tail.

T. Obscurus (Fab.), is similar in form to the foregoing, but the beetle is dull black; the under side, horns, feelers, and feet chestnut color, and the thorax is longer. The larvæ is shining, pale brown, and prefers dry and sound flour, while the other meal-worm prefers damp and damaged flour. *T. molitor* is an old inhabitant of England, but *T. obscurus* has been introduced with American flour, and is sometimes abundant in London and the provinces. Cleanliness is the best guard against these insects, and the meal-worm is a favorite food of nightingales.

Tinea Granella (Linn.), is a satiny and cream white; the head tufted with little, dark eyes; the horns are long and slender, and in front are two spreading feelers, between which is a short, spiral proboscis. The body is blunt in the male, pointed in the female, with a retractile ovipositor; when at rest, the wings slope like the roof of a house, and the fringe is turned up like a tail; the superior wings are long and narrow, freckled with brown, and mottled with blackish spots, two being on the same disk, three on the pinion edge, and toward the apex are three smaller ones; the fringe is long and brown, with two or three pale stripes; the inferior wings are smaller, lance-shaped, and of a pale mouse color, with a fine, long fringe. It has six legs; the hinder shanks long, hairy outside, with spurs at the apex, and a pair near the base; the feet are long and slender. The larvæ of this moth will also destroy books, boxes, and woolen materials, as well as timber and grain. To expel these troublesome and expensive visitors, in the winter the floors

Digitized by Google

should be well scrubbed with hot water and soap, whenever the granaries, etc., are empty, and the walls, ceiling, and beams, must be washed with lime and water as hot as possible. The floors may also be sprinkled with salt dissolved in vinegar; and salt, mixed with the grain, will kill the caterpillars without injuring it. When the larvæ are feeding in the spring and summer, kiln-drying at about 78° of Fahrenheit will kill them; and currents of cold air, by means of ventilators are a safe and certain remedy, as they become torpid and die if a low temperature be sustained. The moths are best destroyed as soon as they hatch in April and May, by burning gas or some such powerful light, which attracts them, and they are at once burnt or rendered incapable of generating the species. Frequently turning over the heaps will also destroy the eggs and young larvæ.

Trogosita Mauritanica (the Cadelle).—This imported insect is sometimes found in granaries and malt-houses in England, but it requires a more southern climate to render it abundant. The larvæ are called Cadelle, in France, where they commit extensive ravages among the stored corn. They will also feed on bread, almonds, rotten floors, and dead trees. They live in this state a year and a half, and when full grown are sometimes nearly three-quarters of an inch long; and by nibbling the outside of the grain they do much mischief. They are flattened, fleshy, rough, with scattered hairs and whitish, tapering toward the head, formed of twelve distinct segments besides the head, which is horny and black, with two sharp, curved jaws; the first segment has two semi-oval brown spots, and the two following, two round ones on each; the tail is horny, with two hooks; and they have six pectoral legs. When they are ready to transform to pupæ, they bury themselves in the earth, or among any refuse at hand; and the beetle which hatches from them is the *T. mauritanicus* of Linnæus, and the *T. carabvides* of Fabricus.—It is depressed, shining, and of a pitchy, or deep chestnut color, and regularly punctured; the head is large, with strong jaws, two small eyes, and before them two short clubbed horns; the trunk is broader, somewhat orbicular, but narrowed behind, and broadest before; with the sides margined, and pointed in front; elytra large, elliptical, with eighteen delicately punctured lines; two wings beneath; six short legs, and four jointed feet. The beetles are long-lived, and said to be carnivorous, destroying grain-moths, etc. See Fig. 64 (5)–(7).

Thrips cerealium (Hal.) is an active little insect, which resides in the spathes and husks of wheat and rye in June, causing the grain to shrivel, and at an earlier period effecting the abortion of the ear, by puncturing the stems above the joints, being the most injurious to late sown wheat. In the larvæ state they are deep yellow, with part of the head and two

Digitized by Google

spots on the pro-thorax dusky; the horns and legs are marked with dusky rings; the pupa is active and pale yellow, with the horns, legs, and wing-cases whitish, the eyes reddish. The perfect insect is larger, flat, smooth, shining, and pitch-color. The male is apterous, the head is semi-oval, with a short stout proboscis beneath, a granulated eye on each side, three simple ones on the crown, and two short nine-jointed horns in front; thorax somewhat quadrate, narrowed before, body very long, and acuminated in the female, which sex has four long narrow wings, lying parallel on the back in repose, Fig. 70 (1), (natural size 2), fringed with very long hairs and adapted for flight (8), (magnified at 4); they have six short stout legs, the first pair of shanks straw color, feet very short, and terminated by a little gland. They are not free from parasites, and a little white mite feeds upon them.

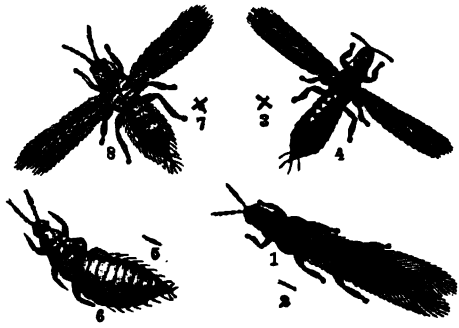


FIG. 70.

T. minutissima (Linn.) lives beneath potato leaves in the summer, and subsists upon the sap. The larvæ are ochreous and sole-shaped, eyes black, horns four jointed (5), (magnified at 6). The pupæ are similar and ochreous. The perfect *thrips* is of a pale dirty ochre color, with two six-jointed horns; the lateral eyes are deep black; the trunk is elongated, the collar sub-quadrate, hinder portions broader, and to this are attached four narrow dirty-white wings, which are fringed with long hairs, and folded parallel on the back in repose; the six legs are short, stout, and simple; the body is pitchy, elliptical, nine-jointed; the tail pointed and bristly (7), (magnified at 8).

Wire-worms.—Complaints are occasionally made of the wire-worm and cut-worm, but a careful cultivation and a proper rotation of crops has lessened the evil produced by these insects.

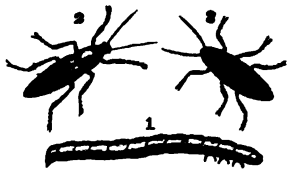


FIG. 71.

A figure of the wire-worm (Fig. 71) is given, the better to communicate a knowledge of its true character. The parent insects (2, 3, Fig. 71) are familiarly known as the snapping bug, from the sound it produces when thrown upon its back in making the

Digitized by Google

peculiar spring by which it regains its position. There are several varieties of the snapping bug, but the one most injurious is a brown smooth bug, which is about an inch long, and is well known to every farmer. The larvæ or worm, which is the incompletely developed offspring of the bug, is about one inch long, having six feet; it is tough, smooth and slender, and is said to continue five years before being transformed into the perfect insect, during which time it feeds upon the *roots* of wheat, barley, oats, corn, and grass. Its ravages are sometimes extensive and desolating. Newly cultivated grounds or meadows, which have not been cultivated for a long time, are most infested by them, but they can be destroyed by cultivation, and if ground be fallowed and exposed to freezing during the winter, this insect, as well as the cut-worm, which has often needlessly been mistaken for it, may be effectually destroyed. Fig. 71 (1) is the worm or larvæ wire-worm; 2 the perfect male insect; 8 the perfect female insect—all of nearly natural size and general appearance. There are larger species which are not nearly so numerous, and hence not so destructive as the one here described.

The true *wire*-worms are the offspring of the elaters or click-beetles, which lay their eggs in the field, where they hatch, become larvæ or wire-worms, are transferred into pupæ, and from these the perfect click-beetles emerge. It is believed that the female elater, of those species so injurious to field-crops, after pairing with the male, lays her eggs upon or beneath the surface of the earth; they are small, round or oval, and yellowish white. The almost invisible worms which hatch from these, immediately attack the crops, whether of corn, turnips, mangold-wurzel, potatoes, cabbages, or grass; and during the five years they are arriving at maturity, they no doubt moult their horny skins several times. When full fed they form, generally in July or August, an oval cell deep in the earth, and casting off the last coat, they are transformed to delicate white pupæ, and in about a fortnight they become perfect beetles. Wire-worms are not much unlike meal-worms, but they are more active, burrowing into the soil with great facility when laid upon the surface. The different kinds resemble each other considerably, the greatest dissimilarity existing in the form of the tail. Sometimes the common wire-worm will ascend into the stem of a plant to feed, and even come forth at night, or in a dull day, to revel upon the leaves; but they prefer keeping beneath the soil, as they can not endure the sun or dryness; and as they dislike cold, in severe winters they retire too deep into the earth to do any mischief at that season. Crows, starlings, sea-gulls, lapwings, pheasants, partridges, wag-tails, robbins, blackbirds, thrushes, fowls, and especially moles, keep down the wire-worms. There are even

Digitized by Google

insects which destroy them—one a ground-beetle, named *Steropus madidus*, and probably many more of the Carabidæ; also a small kind of ichneumon fly (*Proctotrupes viator*), which is very abundant, and examines every chink in the earth to find a wire-worm, to pierce it with its short ovipositor, laying twenty or thirty eggs in its victim, which produce maggots that feed on the wire-worm and destroy it.

The remedies to be employed are numerous, and can only be alluded to here. It seems that turning in sheep and cattle to feed off lays, by treading down the soil and saturating it with ammonia, prevents the beetles from emerging from their cells, and kills the worms. Heavy rolling is also beneficial in the spring. Top-dressings of soot, lime, gas-lime, salt, and nitrate of soda, are more or less preventatives. Hand-picking is a certain remedy; and 12,000 wire-worms have been thus collected from one acre of turnips. Slices of potatoes, turnips, carrots, etc., kept moist under the surface will decoy them. A crop of woad or white mustard will starve and banish the wire-worms.

Zabrus Gibbus (Fab.), (Corn Ground Beetle).—This is one of the Caribidæ, a carnivorous family, which, in its larva and perfect states, is very serviceable in destroying the caterpillars and maggots which infest fields and gardens. Z. gibbus is, however, an exception, for both the larva and beetle feed upon the crops. The beetles run about our grain-fields in July; they are six lines long, very convex and broad, of a pitch color, smooth and shining; the mouth and legs are bright rusty; the jaws are strong; the horns short, slender, and eleven-jointed; the trunk is delicately striated across, with a faint line down the back; there are sixteen finely-punctured furrows on the elytra, with ample wings beneath; the legs are stout, shanks spiny, and formed for burrowing; the fore-feet broadest in the males. Clusters of eggs are deposited by the female in the earth; the larvæ from which are whitish, and slightly hairy; head, thorax, and a stripe down the body brown; the head is large, with short horns, powerful jaws and feelers; and it has six pectoral legs. During the three years they are in this state, they excavate perpendicular and curved burrows in the earth, from a few inches to two feet in depth; and about the beginning of June form oval cells, in which they change to whitish pupæ, with dark eyes.

In Saxony, the larvæ have destroyed two sowings of wheat, and then attacked the rye and barley. They come out at night, and eat into the stems of grain close to the surface, to feed on the pith.

The beetles afterward make their appearance in enormous quantities, concealing themselves under clods by day, and at night ascending the stems to feed upon the soft grain.

Digitized by Google

Anguillula Tritici.—Among the enemies of the wheat plant, the Anguillula tritici, which has been described by British and Continental European writers, but which has not, so far as we know, been noticed by any American authority, deserves a passing notice in the present work. This it does because, although it has not been observed, as yet, to have produced sufficient injury to the wheat crops in North America to have forced itself into notice; yet, from its peculiar nature and characteristics, it may soon become, unless agriculturists are fortified against its attacks by a knowledge of these, a dangerous and destructive enemy.

This worm belongs to the family of Helminthes nematoides, nearly all the members of which are parasites, either of plants or animals, and is the cause of the diseased condition of wheat, known in England as *mildew*, and in France as *niel*, and possesses the very singular property of suffering no detriment to its vitality by complete desiccation, of any length of duration, and of being likewise unaffected by any of the narcotics, or other vegetable poisons, of the alkaloid group, acting upon the nervous system, suffering immersion in these of very considerable extent of concentration of solution, without injury to its vitality.

It is found, in the wheat affected, to have replaced the flour, and produces a shriveled, wrinkled grain, which, upon being broken is found to contain a white powder, which being moistened and examined by means of a microscope, is found to consist of numerous filiform particles, which are *anguillulæ*, or wheat eel-worms. These worms in the mature wheat, examined at any time, are always found without sexual organs, and are therefore to be looked upon as in a transitional state.

When wheat containing them is sown, they are dry, shriveled, and seemingly dead; but, absorbing moisture in the earth, they burst the covering of the grain, and, emerging, find lodgment between the leaves of the growing plant, near the center, where these are yet folded together in the form of an envelop for the forming stalk and head. Fig. 72 is a transverse, segmental section of a young stalk of wheat, magnified 100 times, showing three of the interior leaves, with two anguillulæ between these, as they are rolled or involuted upon each other, and by creeping among these leaves, the worms find their way to the head of wheat, while undergoing that process of development which occurs previous to its "heading out." In Fig. 74, magnified

FIG. 72.

Digitized by Google

100 times, is seen a section of young wheat stalk, upon which two anguillulæ (still in the larva state) are seen, but into the tissues of which they do not find entrance.

Fig. 74.

During the early stages of the development of the wheat-head, while the future chaff, the stamens, ovary, and pistil are yet rudimentary and composed of scales, as it were, of soft cellular matter, the anguillulæ find entrance into the forming grain; but, if they do not reach the head until these parts become distinct, and more consistent, they are then unable to effect their entrance at all.

Until these worms penetrate the forming grain, they undergo no change after being resuscitated by the moisture in the earth, which was supplied to them when the grain was sown; but so soon as they reach the grain, their change from the larva or rudimentary to the adult state takes place, and they then exhibit the sexual organs,—the female is impregnated by copulation, and deposits a vast number of eggs, and, according to the law of insect existence, procreation being completed, the parents perish, while the ova are developed to the larva state in what would have been a wheat grain, and becomes desiccated when this dries at maturity, and there wait a resuscitation when the wheat is sown again in the fall. These larvæ may be desiccated and resuscitated a vast number of times without destroying their vitality; neither are they destroyed by heat which is not sufficiently great to destroy the germinating capacity of grain; nor does freezing kill them unless they are entirely surrounded by water, and they are therefore difficult to destroy, in a remarkable degree.

The injury they effect is seen in the leaves of the wheat, occasionally, which are shriveled and twisted and badly formed, as in Fig. 75, or they present the shriveled, worm-eaten appearance represented by Fig. 76, which is a magnified section of a leaf of mildewed wheat. But the principal or only real damage effected by them is in the grains attacked, which generally give lodgment to eight or ten larvæ, afterward transformed into the perfect insect, and these deposit so many ova that the grain never contains any flour, its development being entirely metamorphosed, and its place supplied by an envelop consisting of the bran, containing the white flour mentioned, and which, at the maturity of the wheat, is completely desiccated.

Digitized by Google

FIG. 75.

FIG. 76.

The appearance of a wheat head attacked by the anguillulæ is very irregular, no one head ever having all its grains attacked; the healthy grains, with their husks or chaff, reach their ordinary development, while the diseased grains present a shriveled diminutive form, and the glumes are contorted and smaller in size than natural, as indicated in the wheat-head in Fig. 75.

These parasites are peculiar to wheat alone, and their propagation may be prevented by choosing clean seed, proper screening, separating the shriveled grains, which should be destroyed by burning, or by being heated in an oven at so high a temperature as to destroy the vitality of the desiccated larvæ, or by soaking the seed wheat for twenty-four hours in a mixture of sulphuric acid one part and water one hundred and fifty

Digitized by Google

parts, which destroys the worm without affecting the germinating capacity of the wheat. Rotation of crops also prevents their multiplication. Care should be taken not to cast the refuse grains upon the manure piles, as the worms, by this means, find their way back to the fields again.

Experiments instituted in France, for the purpose of determining the matter, go to prove that the mildewed wheat, or the wheat damaged by the *anguillulæ*, is entirely innoxious when used as food by men or animals, but greatly lacking in its proper nutritive qualities.

Wheat may be attacked in the same head, even, by other diseases and parasites, at the same time as by the *anguillulæ*; some of which may be prevented by like means as recommended to obviate the attacks of this enemy.

Gortyna Zoæ (Fig. 77).—At the reaping and mowing trial held by the Board at Hamilton, Butler county, July 1, 1857, I found an insect affecting the Barley. In July, 1858, I found the same insect affecting the wheat in the vicinity of Columbus. In appearance, it resembles the common spindle worm *Gortyna Zoæ* (and for that reason I have given it the above name, trusting that some competent entomologist will furnish the proper name); but if fully grown, is considerably smaller. The cut is a correct representation of the living insect and of the normal size. It has sixteen legs, the first pair of pro-legs being rather smaller than the others. The color is a brownish black, the head and first segment yellowish white, with a blackish lateral stripe. The third segment has five white stripes; the lower part of the abdomen being of the same color. The antennæ are very short and hair-like—the jaws brown—the pectoral legs are black, and the pro-legs white. In mode of progression this caterpillar resembles the Geometræ, bending itself in the form of an arch; but the presence of ten pro-legs separates it from that family. It is no doubt closely allied to the spindle worm, and may belong to the same genus. Not having seen the moth, I have no means of knowing whether the transformation to a pupa is undergone in the stem of the plant or in the ground.

Fig. 77.

Besides the noxious insects described, there are many others which future observations will bring more prominently into notice, but many of which are, at present, too little known to enable me to give reliable information concerning them; and will close this description by merely reminding the Ohio agriculturist that all the labor which is bestowed upon a practical study of entomology will be amply repaid by the increased ability to cope with the annoying and dangerous enemies to human happiness, which the seemingly insignificant bug, beetle, and fly, may prove to be.

Digitized by Google

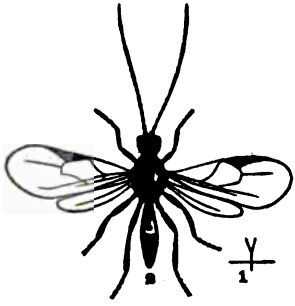


Fig. 78.

The annexed cut represents an European species—*Aphidius avenæ*—Fig. 78, (1 natural size, 2 magnified), which is parasitic on the aphis which feeds on wheat. As the latter insect seems not to be known here, at least to any extent, and we have never heard of any being found, it is not of course an American insect. The Aphididæ are, however, well represented here. Dr. Fitch describes several species parasitic on the green-flies, which feed on several of our fruit trees, etc. All have a general resemblance, and can be easily identified if discovered.

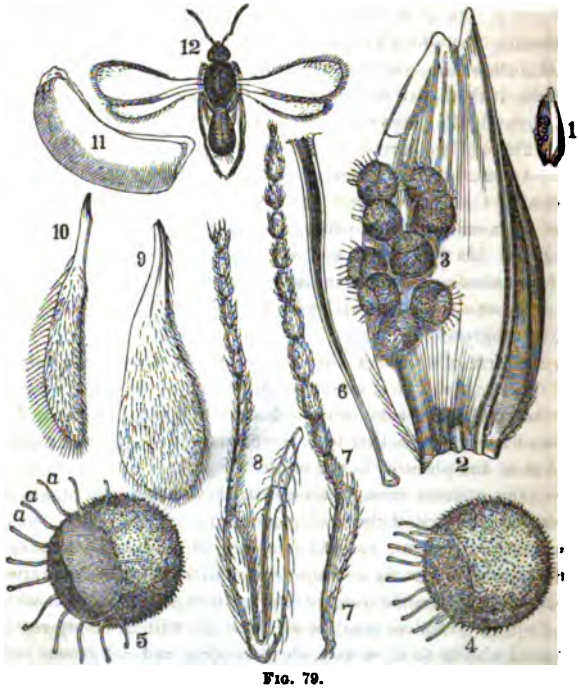


Fig. 79.

About the first of August (1859) Mr. Geo. Heyl brought to my office

Digitized by Google

(in the State House) several heads of the "*Dayton*" or "*Whig*" wheat, as samples for a cabinet which I am collecting. Upon the glume of one of the heads I observed nine small shining black globules, as represented at (1) in the annexed engraving. Struck with their singular beauty, I placed them under the microscope with a low power, when new beauties and wonders presented themselves, as represented at (3); (2) being the glume to which they were attached. They were not only attached to the glume by their bases, but to each other by a very delicate filament, as fine as a spider's thread. On removing one of the globules and placing it under a higher power, it appeared as represented at (4) and (5). The portion inclosed by the spines or fimbria (*a*, *a*, *a*, 5), was discovered to be a movable plate with a convex surface; this plate was removed, and the contents of the globule emptied upon the stage of the microscope. The contents were a transparent sack or larvæ case (11), which, upon being opened, was found to contain a young insect (12) broken into fragments. No. 6 is one of the fimbria (*a*, 5), highly magnified. The antennæ (7) more strongly resemble those of the Cecidomyia tritici than those of any other insect with which I am acquainted; they appear to be made up of ovoid globes garnished with hairs and strung on a delicate filament, but they lack one or two in number to correspond with Bazin's description of the Cecidomyia tritici. (See Ante.) The wings (9 upper, 10 lower) are destitute of nervures, and answer the description precisely of those of the *Platygaster punctiger* as given by M. Sichel, M. D. (see ante), both in shape, relative size, and in being furnished with short prickly hairs. The leg (8) is also that of the P. punctiger.

The body of the globule (4) is of a very delicate texture, readily broken, but has also an internal membrane or lining of an exceedingly delicate texture.

I have hazarded to express the opinion to my friends that it is the larva of the C. tritici partially transformed into a Platygaster. I am led to this conclusion from the fact that in several of the globules I found two wings only, in outline corresponding with those of the C. tritici, and *those had nervures*;—no two of the bodies were precisely alike, and the legs of some strongly resembled those of the C. tritici, while others resembled those of the Platygaster.

It is perhaps indiscreet to publish so imperfect and unsatisfactory an account at present, but by so doing I trust that I am performing one step toward the accomplishment of the main object in view; namely, to direct attention to the study of insects that prey upon the wheat plant. I am the more encouraged in this act of temerity when I reflect that not many years ago the most learned men in Geology published plates and

Digitized by Google

descriptions of the Lepidodendron (a fossil tree) under the name and supposition that it was a fossil fish!

It has been suggested that this insect is a Cynips (gall-fly); I am however, not yet prepared to accept this suggestion.

Should this eventually prove to be the larva of the *Cecidomyia tritici*, then one other method presents itself of avoiding the ravages of this destructive insect; namely, by burning the chaff.

Digitized by Google

HISTORY, CULTURE AND VARIETIES

OF

INDIAN CORN.

Digitized by Google

Digitized by Google

CHAPTER XXII.

HISTORY OF CORN.

On page 53, a brief history of corn was given, in connection with that of some of the other more prominent cereals. A more elaborate article, in relation to its early history, appeared desirable. The subjoined history of the corn plant has been compiled from various sources, and although many of the writers have arrived at different conclusions, each one appears to have been actuated by an honest desire to arrive at the truth only.

The history of the corn plant has been very critically examined and carefully compiled by Mons. Bonafous, a member of the Royal Agricultural Society of France, from whose elaborate folio work, "*Histoire naturelle du Maize*," much of the material of the present account was obtained.

NATIVE COUNTRY OF THE MAIZE.

History sheds so few beams of light on the origin of the maize, that it is as yet doubtful whether this most prolific and beautiful of cereals originated in the Old or the New World. According to some writers, the introduction of maize into Europe is connected with the discovery of America; in the opinion of others, it may be traced back to earlier ages. Bock, the first botanist who spoke of the maize, in a German book printed in 1532, forty years after the discovery of America, says that this plant was brought by Arabia Fortunata into Germany, and that it was named *wheat of Asia, tall wheat*, and *tall reed* (tipha magna). Toward the same time, Ruel and Fuchs confirmed the assertion that it came from the East. "This wheat," says Fuchs, "has come from foreign countries; from Asia and Grecia it passed into Germany, and which caused it to be named *wheat of Turkey;* because the Turks now hold the whole of Asia, and it is on account of the country whence it was derived that the Germans call it *Turkish wheat*." Donicer, Taberna-Montanus, and other botanists, repeat this assertion. The latter gives to the maize the name of Turkish wheat of Asia (Frumentum Turcicum Asiaticum).

Digitized by Google

Being reproduced toward the end of the eighteenth century by Amoreux, and later by Reynier, one of the learned men on the history of agriculture, this opinion found new supporters, who deny to America the boon of having introduced the maize. M. Michaud, in the *History of the Crusades;* Daru, in his *Republic of Venice;* M. de Sismondi, in his *Universal Biography;* and M. de Gregory, in the *Annals of Agriculture*, avail themselves of a Latin charter of the thirteenth century to set forth the assertion that the maize was known to the Old World before the discovery of America. According to that charter, published by Molinari, it was within the year 1204, at one of the epochs when the nations of Europe mingled with those of the East, that two companions in arms of Bonifacius III., Marquis of Montferrat, brought back from Asia-Minor (Anatolia), a kind of white and yellow grain, which they gave to the inhabitants of Incisa, a burgh of High Montferrat, under the name of *meliga.* The magistrates, remarks the historian of the Crusades, received with solemnity the innocuous gifts of victory, and caused to be blessed on the altars a produce which was one day to enrich the fields of Italy. The word *meliga*, which is read in that charter, and those of *melica* and *melya*, are also found in divers authentic documents of the middle ages. The latin word *melica* is again met with in one of the ancient chronicles, published by Muratori; and Crescenzio, the father of Italian agriculture, in his treatise of rural economy, written over a hundred years before the first voyage of Christopher Columbus, says that in Italy they raised two species of *milica*, one red, another white. Crescenzio explains the manner of cultivating the plant which he calls *milica*, and that mode is the same which is now used for the maize.

Again, we read that a Portuguese author, Santa Rosa de Viterbo, infers from a deed of the year 1289, that maize was known during the thirteenth century, in Portugal; the deed reads as follows: "In a will of S. Simon of Junqueira, dated 1289, it is said: *Bequeathed to Steven John of Perafita, or to his heirs, one quarter of milhom.*" Such an inference is in accordance with the opinion of Valcarel and other authors, who affirm that the Arabs brought the maize into Spain. But a stronger testimony is offered to our inquiries, by the very image of this plant found in the Chinese work of Li-chi-tchin, composed toward the middle of the sixteenth century. The few years intervening between the publication of this book and the discovery of America, scarcely admits the supposition that the introduction of maize into China was due to that discovery, because every body knows how secluded the Chinese are; whose slowness in adopting foreign culture is proverbial. John Crawfurd, who resided in the island of Java during nine years, is inclined to believe that the maize cultivated since the earliest

Digitized by Google

ages in the Asiatic islands, situate under the equator, between Continental Asia and Australia, may have passed from these islands into China and spread as far as the Himalaya, where Heber observed it. "Maize," says J. Crawfurd, "is next to rice the principal produce among the great tribes of the Indian Archipelago. The word *Jagung*, which is believed to correspond to *indigenous*, is the expression under which this plant is known from one extremity of the Archipelago to the other; there could, therefore, be little doubt that a single tribe must have instructed all others in that cultivation, as we saw it was done with that of rice. Such a fact can not be demonstrated, but we are allowed to think that maize was cultivated in the East Indies before the discovery of America, and that this plant is an indigenous product. The name of maize has no analogous word in the American tongues, although, concerning animal and vegetable exotic productions, they have invariably adopted, in all the Indian Archipelago, either the primitive name, or such as to show the origin of the plant. It suffices to quote as an example the pepper plant, the mangoo (*mangifera Indica*), the hairy kidney bean (*phaselous Max*, D. C.); the ewe which was introduced by the Hindoo; the orange-tree and the arachide, natives of China; the coffee-tree, received from America through European nations."

Finally, a conclusive proof of the maize existing in the Old World, at one of the earliest epochs, would be its presence within the monuments of the highest antiquity. M. Rifaud, known by excavations which he had made in Egypt, affirms to have found grains of that plant within the tomb of a mummy discovered at Thebes in 1819. The following details extracted from the unpublished narrative of this traveler, and directed to me, deserve of being literally communicated.

"The grains and the ear of maize which I have discovered at Gournac (Thebes), were found, says M. Rifaud, under the head of a mummy, laid on a wooden cushion. The grains were within an earthen bowl, the stem, eighteen inches long, still preserved its leaves. On the left part of the mummy were seen small fruits, named in Arabian *nabac*, mingled with some grains of wheat and bulbs of a plant wherefrom the inhabitants manufacture their beads. On the right part were aquatic vegetables, named in Arabian *resche;* there were also five or six loaves of wheat bread. A garland and a crown of lotus blossoms ornamented the corpse of the mummy. The coffin, made of sycamore wood, covered with hieroglyphics, was inclosed within a sarcophagus of basalt; three hundred and ninety small figures of baked earth surrounded the mummy. The wooden box was five feet seven inches long, and the basalt sarcophagus was about six feet. It was at the western part of Thebes,

Digitized by Google

on the declivity of the Libic range, that I made this discovery, altogether accidental, since the little valley wherein the tomb lay concealed had been explored by the Arabians during several years."

Such are the authorities and principal documents that may be brought forth to support the claim that the maize originated in the Old World. But before declaring any decisive opinion, I will present in the same order those which might establish the American origin of that plant, and with this assumption, show that the name of *Indian wheat* came to our forefathers, from the idea that the new continent was a part of the Asiatic regions, comprised then under the general name of India.

At first, against the assertion of Bock, Ruel, De Fuchs, and other botanists, who pretend that maize came from the East, we may array the opposite affirmation of no less celebrated writers, such as Camerarius and Mathioli; the former in a work printed in 1588, invalidates Fuchs' opinion by assuming that maize was brought from the West Indies, and not from Asia; the latter, a most learned man, speaks thus about that plant:

"We may reasonably include among the wheat that which is wrongfully called *Turkish wheat;* I say wrongfully, because it ought to be named *Indian wheat* (formento Indiano), and not *Turkish wheat*, because it came to us from the West Indies, and not from Asia or Turkey, as Fuchs believes."

Dodoens, Ray, and other botanists, either contemporaneous or subsequent, declared that Fuchs was mistaken, and that maize came from the New World.

Furthermore, the name of Turkish wheat, or wheat of Turkey, given to maize probably at the time of its introduction, and which it still preserves, indicates no better its origin than the name of wheat of Egypt (*misrbogday*), given to it by the Turks, or *dowrah* of Syria, by the Egyptians, and *Sicilian grain*, by the Tuscans; while it is called *Indian wheat*, in Sicily; *wheat of Rome*, in Lorraine and Vosges; *Spanish wheat*, at the foot of the Pyrenees; *wheat of Guinea or Barbary*, in Provence. These names, taken from the countries in which maize was cultivated at various periods into neighboring regions, prove no more conclusively its place of nativity than the names of *Italian poplar* and *rice of Carolina*, demonstrate the spontaneous growth of the former in Italy, of the latter in America. The name of *Turkish wheat* seems to me as improper in regard to maize, as the word *turkey* (fowl of Turkey), used by the English to designate a *cock of India*, a native of America.

Some authors, M. Dumeril among them, have thought that maize had been named *Turkish wheat* on account of the long silk with which ears

Digitized by Google

of female corn are garnished. It is useless to combat this explanation; the costume of wearing plumes on the head being not peculiarly and exclusively Turkish.

Let us examine, now, whether maize is well indicated by the words *meliga*, which is read in the charter of *Incisa*, and *milica*, which Crescenzio and others used.

The minute description of the species of grain brought from the East into Italy, at the beginning of the thirteenth century seems, it is true, to answer for grain of maize, the basis of which inserted into the ear's axis is white, while the outer portion is yellow in many varieties; but according to the interpretation of the word *meliga* by the learned author of the *flora of Egypt*,* the same may be applied to sorgho or millet of India (*holcus sorghum*, L.), the grains of which pass in some varieties, from yellow to white. When we interrogate other authors upon that score, we are answered by Cardan, from the sixteenth century, that the wheat cultivated at the Western Indies, under the name *mais*, approaches by its stature the plant designated in Italy by the name of *milica* or *sorghum*. At the same time Caspar Bauhin said that the Lombards named *melaga*, the plant known as *saggina* in Tuscany. Mathioli, who, without doubt, did not confound the two plants, assures us that the one known under the name of *melega*, was called *melica*, in Lombardy, *saggina* in Tuscany, *sorgho* in many regions of Italy. George di Turre, an Italian botanist of the seventeenth century, says also with Cardan, that the maize or Turkish wheat, imported into Italy, a few years since, produced a stem similar to that of the plant named *meliga* or *sorghum*. The academicians of Crusca, whose authority bears a great weight in regard to language, render, in their vocabulary, the Italian word *meliga* (in Latin *melica*) by *saggina*, finally Targioni-Tozzetti, author of a botanical dictionary, justly esteemed, translates the words *holcus sorghum*, L., by *melega*, *melica*, *melliga*, *miglio indiano*, *panico indiano*.

It is only in the Piedmontese dialect that the name of *melia* or *meliga* is given both to the *zea* and *holcus*, nevertheless distinguishing the latter plant from the former by the words *melia rossa* or *melia da ramasse* (*red maize*, or *broom maize*); while in Italian language maize receives the name of *grano Turco*, *sorgo Turco*, *formentone*, *granone*, *grano Siciliano*, *grano d'India*, and so forth.

Therefore, neither the charter of Incisa, nor the quotations from Crescenzio and others, can decide the question, as long as it shall not be proved that *meliga* or *melica* is a true maize. The grain brought

* Description of Egypt, published by order of Napoleon I., Nat. History, Vol. 2, see the splendid copy given by France to the United States, Smithsonian Institute.

Digitized by Google

by the Crusaders, might be a variety of sorgho or millet of India, then unknown in the Montferrat.

Again, Crawfurd's opinion upon the Indian origin of the maize, how well grounded soever it may appear, is counteracted by M. de Humboldt. "There is no doubt," says this universal savant, "in the minds of botanists, that *mais* or *Turkish wheat* is a truly American *wheat*, and that the new world gave it to the old world. When Europeans discovered America, *zea maiz*, in Azteck language *thaolli*, in Haitian *mahiz*, in Guichua *cara*, was already cultivated from the southern region of Chili as far as Pennsylvania. According to a tradition of the Azteck nations, the Toultecks introduced, during the seventh century of our era, the cultivation of maize, cotton, and pimento, into Mexico. It might, however, be true those various branches of agriculture were practised before the Toultecks, and that this nation, whose advanced civilization was extolled by historians, did nothing but spread it with success. Hernandez informs us that the very Otomites, a barbarous, wandering tribe, planted the maize. The cultivation of that plant was therefore extended even beyond the Rio Grande of Santiago, formerly named Tololotlan."

Indeed, no doubt can be entertained that the maize was cultivated among the Americans, when P. Martyr, Ercella, John de Lery, Laet, Torquemada, and others, relate to us that the first Europeans who landed upon the new world saw there, among other marvels, a gigantic wheat with long smooth blades, elegant stem, and golden ear; this marvelous wheat was the maize. Several nations celebrated its harvest amid religious ceremonies; at Cusco, the holy city, abode of the Incas, the virgins of the Sun prepared with that precious corn the bread of sacrifice, tinged with the victim's blood. In Mexico, they formed with it idols, which the priest broke, and distributed the fragments thereof to the multitude. A goddess Ceres, worshiped under the name of *cinteutl*, derived from *centli* or maize, in Mexican language, received as an offering the harvest's first fruits. Every nation in Mexico, Peru, Brazil, Orinoco's plains, Antilla Islands, were nourished with that grain. Maize, cultivated over a space ninety degrees south and north of the Equator, was the wheat of the new hemisphere; it was there used as money or standard of exchange; and the law, among Mexicans, condemned to death whoever stole seven ears of maize.

In the books of Homer and Theophrastus, people believed to trace the maize by the name *zeia;* in calling it *zea*, Linnæus propagated that notion. Andres de Laguna, in his commentary on Dioscorides, Lobel and Olivier de Serres, supposed that the black millet brought from India into Italy during the time of Pliny was the maize. Lobel gave

Digitized by Google

the figure of the maize under the name of *milium indicum Plinianum*; but these conjectures are not well grounded. The *zeia* of the Greeks, as admitted by M. Fee, the faithful interpreter of Theocrites and Virgil, was assuredly the *zea* of the Latin, now a kind of wheat named spelt (L. *triticum spelta*). The characters assigned to *zeia* by Theophrastes, are so positive that they can not be misunderstood; and the plant with black grains indicated by Pliny, should be the black sorgho, the *tine* of the negroes (*holcus niger*, Gml.), which is distinguished by the black color of the shell which covers the grain; it was, perhaps, a variety of *mil* (miglio), spoken of by Anquillara during the sixteenth century.

The celebrated orientalist, d'Herbelot, quotes a sentence from Mirkhond, a Persian historiographer of the fifteenth century, the translation of which, if faithful, would leave no doubt as to the maize being known to the ancient world before the discovery of America. According to d'Herbelot, Mirkhond says: Rous, Japet's eighth son, caused to be sown within the islands of Caspian sea, the wheat that we call *wheat of Turkey*, and which the Turks name still in their language *rous* and *boulgar*. In order to verify this quotation, the book of Mirkhond at the Royal Library of Paris was examined, and ascertained that the Persian author, at the place indicated by d'Herbelot, relates that Khozar, son of Japet, caused to be sown on Volga's banks, some *Kaveres*, a kind of corn which the dictionaries render by millet, yellow millet, millet of Khatay; and that Rous, Khozar's brother, caused to be cultivated on Volga's islands the *borgon*, which signifies, according to the same dictionaries, a kind of hollow tree from which flutes are made. The word *borgon* would then have been confounded with *borgoul* or *borgul*, rendered by authors as *alica*, *frumentum seu triticum*, *far decorticatum*; and from the word *bolgour*, d'Herbelot would have made *boulgar*, which vocabularies translated as *leather*, and not as any grain whatever. As to the word *rous* meaning maize or grain, I found nowhere an expression to support d'Herbelot's account. Either this author has drawn from a source different from that which he indicates, or a strange confusion befel the documents which he had collected.

Harmentier, and other subsequent writers, suggested as a negative proof, the silence of the voyagers who visited Africa and Asia in ages previous to the discovery of America; but these travelers having not explored all regions of Asia and Africa, it may be objected that they did not see those where maize was cultivated.

Besides, could we not trace the maize from a period of Diodorus of Siculus, when that historian relates that a Grecian adventurer, named

Digitized by Google

Iambol, visited, in the sea of India, an island where a kind of reed grew which abundantly bore a precious grain, similar, in its form, with that of the orob. "They gather it," said Iambol, "and they allow it to macerate in water, until it obtains the bulk of a dove's egg; then after pounding and kneading it with the hands, they make loaves which are baked in ovens, and that bread has a very sweet savour." That grain, unknown to Diodorus, might be the maize, and the island whereat Iambol observed it was Taprobane of antiquity, now Ceylon, or Sumatra, according to various opinions.

To the above conflicting authorities many more could be added: evidently there is no lack of facts or deeds for their support; but those which I have gathered seem to me sufficient to base the following propositions:

1st. The charter of Incisa, and the quoted authors failing to establish, in a positive manner, that the plant named *meliga*, or *melica*, was really the maize, these testimonies afford no complete proof.

2d. The dissenting opinions of the botanists, during the sixteenth and following centuries, about the origin of the maize, do nothing but cast doubt on the Eastern or American origin which is attributed to it.

3d. If it were certain, as historians assert, that maize was cultivated in America, when Europeans landed there at the end of the fifteenth century, it would appear equally true that this plant was in full cultivation within India at anterior epochs.

4th. The treatise of Natural History, by Li-chi-tchin, written toward the middle of the sixteenth century, marks the existence of the maize in China, within a time so close to the discovery of America, that this event must not be connected with the introduction of that plant into Asia.

5th. In conclusion, the maize found at Thebes, within a mummy's coffin, after a lapse of thirty or forty centuries, would be a precious but solitary relic, which would prove that maize existed in Africa since the earliest time.

These various points being admitted, there is enough to conclude that maize was known to the old world, before the discovery of America; that probably the Arabs, or the crusaders introduced it first into Europe; and that subsequently the discovery of America gave occasion for another introduction, and wider extent of cultivation of this plant, heretofore confined within narrow bounds.

But let it be granted that the presence of the maize, within the two worlds, may be attributed to its spontaneous production on both hemispheres, or one of them only; and that, in this last conjecture, it may have migrated from one to the other with their ancient nations, it is

Digitized by Google

probable that the first dwelling-place of the maize will remain uncertain until we discover the place where it grows without culture, granting that the revolutions which the earth has experienced render such a discovery not impossible.

BOTANICAL DESCRIPTION OF CORN.

Zea Mays or Indian corn forms a genus of grasses characterized by its monœcious flowers—(that is, it has both male and female flowers, while the flowers of the wheat plant are hermaphrodite, or male and female included, and each forming a portion of the same flower—) forming a terminal panicle (tassel); each spikelet containing two flowers, each with two palæ and three stamens. The female or fertile flowers (ear) form a long, dense spike, completely enveloped in a number of sheathing floral leaves (husks), from which the thread-like stigmites protrude to a great length; the spikelets, as in the males, contain two flowers, but they have no stamens; one flower has an ovary with a long style ending in the above-mentioned thread-like forked stigmate; the other flower has only two empty pales.

Explanation of the Plate.

Young ear of maize released from its spathæ.

Fig. 1, one of the axillary boughs bearing female blossoms set in the shape of an ear; every bough bears from one to four ears; this specimen is, in the flowering period, exposed to view by the removal of its lower spathæ, and by the opening of the two upper ones (*b. b*).

a, a, bundle of styles, the top of which only is seen when the spathæ *b* incloses the ear; each style is inserted upon one grain of the ear, but they are removed in order to show the arrangement of the grains on the cob which supports them; this order is liable to many variations. The grains are often closely set two by two, and form longitudinal lines straight or spirally, winding from left to right; the number of these rows is variable, but always even.

Fig. 2, *Male blossom isolated a little magnified.*

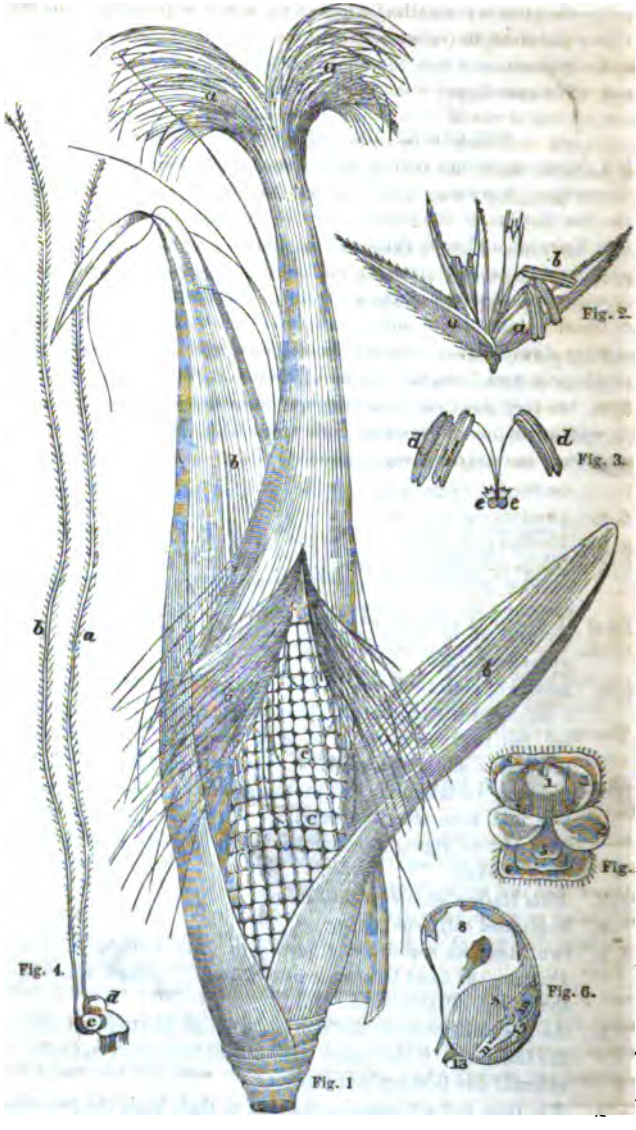
a, bi-glumed calix containing

b, c, two blossoms somewhat differing in form and size with their glumes; the fixed blossom *c* has two small glumes about equal, sharp, and ciliated at the top.

b, the pediceled blossom has also two glumes, smaller and uneven; the innermost is shortened with a double-pointed summit; the external one is sharp and shorter.

Fig. 3, *The three isolated staminæ,* showing at their basis the two small-

Digitized by Google



Digitized by Google

est glumes (or glumellulæ), *e e*, swollen and greenish at the basis, and surmounted with a white, scarious truncated membrane.

d, d, stamens.

Fig. 4, *two ovaries*, surrounded with

c, their shells fastened to a portion of

d, the cob, each of them surmounted with

a, b, their style, laminated, hairy, greenish, grooved in the middle through its length, which indicates two styles soldered into one naturally divided at the top into stigmatæ; sometimes there is but one of them, the other being abortive.

Fig. 5, *female blossom* of which the glumes and glumellæ are forcibly opened in order to show.

1, the whole ovary and

2, its two glumellæ so deeply bi-lobed, that we would be inclined to believe them to be four in number.

3, 3, two of the three subulated points which are three glumellulæ situated at the basis of the ovary.

4, 5, are the center blossom of which 5, the smaller glumellæ, is laid on the larger external one, 4.

6, 6, two large glumes or calyx containing the two blossoms.

Fig. 6, *Vertical section magnified of the perisperm*, 8, *and embryo;*

9, thickness of the cotyledon; 10, plumula; 11, radicle; 7, cavity variable, but always placed toward the center of the perisperm. We always find at the lower extremity of the embryo a somewhat large plate, black, thin, membranous, inert, which was not as yet pointed out, and may be the remnants of the ovulary bag; 13, its place and section.

The maize is a stout, erect annual, growing from the hight of four to sixteen feet, according to the variety, soil and season. The leaves are from one to two feet long, and from two to three inches broad. The panicle (tassel) is divided into long branches on short stalks. The female spikes (ear) are generally two or three in number, placed at or below the middle of the stem; they are often over a foot long and thicker than the wrist. The axis (cob) is a thick, hard pith, on which the grain is very closely packed in a number of regular longitudinal rows, differing in color, size, and form, according to variety.

Ever since the settlement of the United States, corn has been the most prominent cereal cultivated in the Middle, Western, and Southern States. From the earliest settlements in Ohio, it has been the most important crop in the southern portion of the State; indeed, it must be regarded as inferior to no other crop, for the reason that for family use it occupies a conspicuous position, and for wintering and fattening domestic

Digitized by Google

animals, is indispensable. Then, too, the leaves and stalks furnish a fodder very much superior to the straw of any other cereal.

There is no cereal grown with less difficulty than corn, yet there is no other that repays good culture so well; at the same time it can not be denied that its perfection depends in a much greater degree upon the season than any other crop. As a general thing, however, if July and August prove favorable, a good crop may safely be relied on—from the fact that early frosts and late-continued rains, like those of 1857, do not occur once in a decade of years—they are, therefore, the exception and not the rule.

Mr. Salisbury, the analytical chemist of the New York State Board of Agriculture, says: "Very little has been done by chemists, which is calculated to throw light upon the composition of corn. All the analyses which have hitherto been published, are incorrect as well as imperfect." He, therefore, commenced a complete series of detailed analyses, commencing with the plant when it weighed, in a dry state, only 26 grains, and analyzed specimens, of which each succeeding one was from five to eight days longer growth than the preceding one, until the corn was fully ripe. From his detailed and elaborate statements, published in the Natural History Survey of New York, I have compiled the following analyses. The annexed table gives the amount in grains which the several parts of the plant weighed when dried, also the amount of water which they contained, and the amount of ashes they produced. The plants were taken up respectively on the 5th of July, 4th of August, and 18th of October, at which latter period the corn had fully matured.

July 5. Hig't of plant, 36 inches.	Kernels.....	Cob.....	Tassels.....	Top Stalk.....	Butt Stalk.....	Sheaths.....	Leaves.....	Sheathe of Husks..	Ear Stalks.....	Silks.....	Joints of Stalks....	Roots.....
Water.....			54.8	92.5		181.1	304.					70.3
Dry Matter,.			6.2	8.1		106.0	63.					19.1
Ash,.....			0.6	4 9.		15.0	6.7					1.6
August 4.												
Water.....		396.4	115.5	62.5		2110.	2079.	2180.5		629.5		
Dry Matter,.		36.6	66.5	654.5		514.	631.	330.5		70.5		
Ash,.....		3.5	4.7	29.4		32.	58.9	12.22		4.		
October 18.												
Water,.....	374.6	295.	54.9	864.3	2425.9	525.7	946.7	529.2	354.6	66.4	216.3	427.6
Dry Matter,.	625.4	211.	78.1	159.7	360.	218.3	635.3	2 3.8	44.4	14.2	41.1	128.4
Ash,.....	8 0	2.9	9.2	11.2	26.6	22.5	79.8	13.4	1.2	.9	2.8	5.3

Digitized by Google

OBSERVATIONS, PARTS AND PROPORTIONS.

October 18—corn ripe. The amount of water in the stalks, leaves, and sheathes has gradually decreased since the 13th of September. The kernels have gradually increased in specific gravity since their first appearance.

RELATION OF THE PARTS OF PLANTS TO EACH OTHER.

	QUANTITY.	PER CENTAGE.
Tassels,	133 grains.	1.068
Top Stalk,	1026 "	8.239
Butt Stalk,	2786 "	22.375
Sheathes,	744 "	5.975
Leaves,	1584 "	12.721
Sheathes of Husks,	768 "	6.126
Stalks of Ears,	299 "	2.401
Silks,	81 "	.651
Roots,	556 "	4.465
Kernels,	3468 "	27.852
Cob,	1012 "	8.127
	12452 grains.	100.

INORGANIC ANALYSIS OF THE PLANT.

October 18, Corn Ripe.	Stalks,	Sheathes,	Sheathes of Husks.	Leaves,	Tassels,	Roots,	Ash of Kernels,
Carbonic Acid,	1.8	trace.	trace.	4.	*	*	trace.
Silicic Acid,	12.8	51.2	47.6	58.6	61.0	23.6	8.5
Sulphuric Acid,	1.07	12.2	6.6	4.8			0.5
Phosphoric Acid,							60.8
Phosphates,	15.1	9.7	26.2	5.8	9.8	11.8	
Lime,	2.8	2.1	0.4	4.5	2.3	4.6	.07
Magnesia,	0.9	0.8	trace.	0.8	0.6	1.0	6.5
Potash,	16.2	7.4	3.5	7.8	6.8	11.3	28.1
Soda,	24.6	12.4	9.8	8.5	8.8	25.4	3.6
Chlorine,	10.9	2.9	5.5	2.6	10.3	22.	0.3
Organic Acids,	3.2	trace.		2.2			5.7

* The analyses of Tassels and Roots are not complete.

Digitized by Google

The amount in pounds of elements removed in the entire crop of an acre of corn, yielding an average return, is as follows:

	Tassels, ..	Stalks,.....	Leaves,.....	Sheathes, ..	Husks,.....	Cob,.....	Kernels,...	Total,.....	
								lbs.	oz.
Silica, ...	5.01	8.78	82.68	39.66	26.92	4.67	5.93	173	12.4
Earthy Phosphates,.....	0.82	10.36	29.27	7.54	14.88	8.22	22.18	93	8.9
Lime, ...	0.19	1.92	9.40	1.58	0.25	0.10	0.10	13	9.2
Magnesia, ...	0.05	0.64	1.91	0.58	0.04	0.30	1.50	5	0.7
Potash, ...	0.57	11.08	19.70	5.57	1.98	12.31	14.95	66	2.9
Soda, ...	0.74	17.09	13.14	9.26	5.55	2.03	14.11	61	15.1
Chlorine,.....	0.19	7.49	15.07	2.20	3.14	0.04	0.30	28	7.3
Sulphuric Acid,	0.33	7.38	6.46	8.92	3.77	0.11	2.74	29	11.6
Total,.....	8.02	64.77	177.64	75.35	56.49	27.83	61 84	471	15.6

An organic analysis of the Ohio Dent Corn, which is one of the largest varieties of this cereal grown, is as follows:

	Ohio Dent.....	White Flint.....	Eight-rowed Yellow.	Sweet Corn.....	Tuscarora.....	Pop Corn.....	Golden Sioux, or Beal's Dutton.....
Starch,.....	41.85	40.34	30.29	11.60	48.90	46.90	36.06
Gluten, ...	4.62	7.69	5.60	4.62	undetrmd.	9.24*	5.00
Oil,.....	3.88	4.68	3.90	3.60		6.96	3.44
Albumen, ...	2.64	3.40	6.00	14.30	8.72	5.02	4.42
Caseine,.....	1.32	0.50	2.20	5.84	2.32	2.50	1.92
Dextrine, ...	5.40	2.90	4.61	24.82	2.00	2.25	1.30
Fiber, ...	21.36	18.01	26.80	11.24	14.00	8.50	18.50
Sugar and Extractive,.....	10.00	8.30	5.20	14.62	10.00	7.02	7.25
Water,.....	10.00	14.00	13.40	10.32	13.68	12.12	15.02
	101.07	99.72	98.00	100.96	99.62	99.51	100.05

There is no plant, whether cereal or other, which so readily hybridizes or intermixes as corn. Every one who has grown corn, is well

* Including Sugar. † Exclusive of Sugar.

Digitized by Google

aware of the difficulty of keeping the varieties pure. If a single red grain is planted with white or yellow grains, all of the corn, not unfrequently, within the space of a rod in each direction from the red stalk, will have more or less red grains on the cob. Several experiments are recorded of the impregnation of one variety by the pollen of five or six distinct other varieties, and when the ear matured, there were five, six, or seven varieties of kernels on the same ear. The pollen from the tassel is the male portion of the plant, and the silk from the ear is the female portion; it follows, necessarily, that if the tassel of the red corn referred to above, be removed before it is mature, that there will then be no pollen to be shed on the surrounding stalks, and consequently it can not propagate its variety. If the silk be removed as soon as it protrudes through the husk, it can not be impregnated, and although the ears may perhaps produce grains of corn, yet they will be deprived of all germinating power.

As with the wheat plant, climate, soil, and culture have materially modified the corn plant, and produced a great number of varieties, each of which has habits peculiar to itself—has, in a word, as much a fixity of type as any variety of wheat; but it readily acclimates, and in the process of acclimation has its typical character much modified.

I have very little doubt that the *Oregon* corn, as it is called, is the original corn plant of America. In this variety each grain is enveloped in a separate husk, or sheath, but when it is cultivated with other varieties, for a series of ten or twelve years, these husks disappear; the cob grows larger and compact, and in every respect resembles the ordinary corn.

CULTURE OF CORN.

Corn thrives best on a sandy loam, or bottom lands; in a stiff clay it never succeeds so well, although some good crops have been grown on clays which have been long in a state of cultivation. The bottom lands, like those of the Scioto, Miami, and Muskingum valleys, appear to be best adapted for the growth of this cereal, in its greatest perfection. Corn succeeds well on lands after several crops of wheat also, but farmers generally prefer breaking up "sod ground" for a good crop of corn. Practice indicates that a soil rich in humus, or decayed and decaying vegetable matter, is much better adapted to corn than that destitute of this material; for this reason it is good policy, to say the least, if not really advisable, to grow corn after wheat, in order to remove the vegetable matter formed by the roots of the wheat; for the same reason it succeeds admirably on sod ground, because it removes the humus created by the roots of the grasses.

Digitized by Google

The ground should be well manured and finely pulverized to insure a good crop, and this is the reason why loamy soils are uniformly more productive than the clays, for the reason that there is less cohesion among the particles of the soil, whereas clay, as is well known, is exceedingly tenacious.

It will flourish on the best wheat land; but wheat will not succeed well on the best corn land. To grow corn on land that will produce good wheat, is not, as a general rule, to be commended.

I have said that corn will succeed on land too low for wheat. This is true; but corn requires a dry soil. It is a mistake to suppose that all high land is dry, and all low land wet. Mr. Swan, near Geneva, New York, who laid over fifty miles of drain-tiles on his farm, found that the highest part of his farm required as much again draining as the lower portions. On low land, a few open ditches are often sufficient to carry off all the water; but on a springy hillside, thorough underdraining is necessary.

Land for corn must be dry. We recollect, says the Genesee Farmer, walking through a magnificent field of corn on the thoroughly underdrained farm of our friend John Johnston. One of the underdrains was choked up, and *there the crop was a failure.* Corn delights in a loose, dry, warm soil. If it is surcharged with water, all the sunshine of our hottest summers can not make it warm, and all the manure that can be put on it will not make the corn yield a maximum crop. In passing along the various railroads, we have often been saddened to see thousands of acres of land planted to corn, which, by a little underdraining, would have produced magnificent crops of this grandest of cereals, but which presented a miserable spectacle of yellow, sickly, stunted, half-starved plants, struggling for very life. We have ever been willing to apologize for the shortcomings of American farmers. We know the difficulties under which many of them labor. We *do* believe them to be, as a whole, "intelligent and enterprizing." But these sickly corn-fields are well calculated to create a very different impression. We have frequently to repeat the German proverb—"To know is not to be able." These farmers know how to raise good corn, but they are not always able to put in practice improved methods of cultivation. Many, however, might do better than they do. The country is in an embarrassed condition. Willing hands can not find labor. Good crops alone can save us from still greater poverty and suffering. One good harvest would set the wheels of trade and manufacturing industry in motion, and usher in a gladsome period of national prosperity. But it is in vain to hope for good crops without good cultivation."

Constant stirring of the soil decomposes its organic matter, and

Digitized by Google

renders available the food of plants lying latent in it; it enables it to attract ammonia, and to condense moisture from the atmosphere, while it furnishes a loose and warm bed for the roots to grow in.

Deep culture is also indispensable. There is scarcely a plant which does not thrive much better in a loose, deep soil, than in a shallow, compact one; but in no case is this fact susceptible of more ready verification than in the corn plant. One instance only may be cited to illustrate the effects of deep culture. There is in the immediate vicinity of Columbus a tract of "*Scioto bottom land*," which has for upward of forty years been cultivated in corn annually. In 1851, Mr. John L. Gill, of Columbus, anxious to test the effect of deep culture on corn, plowed eleven acres and about three-fourths to a depth of about eight inches, with a double plow, and then followed with a subsoil plow, loosening but not turning up the soil, to a depth of eight inches more. This tract, as well as the neighboring one, had never been plowed to a depth exceeding six or seven inches. In 1851 the neighboring pieces were plowed the usual depth, and planting completed on the 7th of May; Mr. Gill completed the planting on the 10th.

In the course of three weeks the corn in the neighboring tracts appeared as forward and thrifty as usual, while that of Mr. Gill appeared pale and rather dwarfed—this, to say the least, was rather discouraging. But in the month of July, that in the neighboring fields appeared to have come to a "stand still,"—the leaves curled and drooped, and gave unmistakable manifestations of sufferings from drought, while Mr. Gill's was growing vigorously, and indicated no lack of moisture. The result was that Mr. G. obtained 120 bushels per acre, while the adjoining fields yielded less than forty bushels per acre. This fact is well authenticated, and the field was witnessed in July and August by thousands of persons.

While the stalks in Mr. G.'s tract presented a pale and sickly appearance, the roots were pushing downward in search of moisture and nourishment; finding abundance of this, a sufficient supply was stored for the growth of the plant to resist all effects of drought. That in the neighboring fields exhausted the supply at first, and when the drought set in it had no store of supply to fall back upon.

Selection of seeds.—The ears which ripen the first should always be selected for seed, and not all the kernels on the ear should be planted. The largest and best developed grains only should be planted; those at the base and apex of the ear invariably tend to degenerate the variety. After they have been selected they should be placed in some dry, cool, airy place, but should not be exposed to the open air of severe midwinter.

Digitized by Google

Many farmers pursue altogether too hap-hazard a method of providing themselves with seed corn. The crop of corn in a field will be much less where seed comes up badly, and where there are hundreds of vacancies in places where corn stalks ought to be. It is believed to be not an uncommon case that a farmer loses at least five bushels of corn to the acre on account of poor seed. The loss sustained through the entire West must therefore be immense. And yet with a little attention there is really no difficulty in providing good seed. In the month of September, when the husks on most of the ears of corn begin to whiten, showing a commencement of the ripening of the grain, go through the corn-field selecting good ears. In husking them, leave two or three husks, for the purpose of braiding several ears together. Suspend these over poles, affixed in some of the out-buildings, and let them remain till planting time in spring. This method of securing good seed corn has been known to me from boyhood. As a proof of the excellency of this plan, I have now on hand two or three communications giving the practical experience of good farmers who have tried it.

One correspondent writes from Yellow Springs, saying that he lately met with a Mr. James Justice, an old farmer from Indiana, 70 years of age, who stated he had uniformly supplied himself with seed corn in the manner above related for more than thirty years, and that he never failed in having good seed; that his corn plants in spring, when first pushing out of the ground, exhibit a vigor of growth and a vitality of constitution that remain visible throughout the entire season. And the following on this same subject I publish in full.

Saving Seed Corn.—I gather my seed early in September, when about half the ears of the field intended for gathering seed from have their husks whitened with ripeness, showing ears that have matured. The secret of the whole matter may be understood at once; be sure to have seed corn perfectly dry before freezing weather comes upon it. This method, be assured, if carefully attended to, will save much trouble and perplexity in starting your corn crops. I leave enough husk on each ear to tie two and two together, and hang on poles in a dry airy place, two ears deep to each pole.

Soaking corn in water has all the effect so far as hastening growth is concerned, that soaking in any of infinite solutions recommended would have; at the same time it may be advisable to soak the corn in some mineral solution, and then roll it in plaster of Paris, lime, or even tar, to render it unpalatable or poisonous to cut-worms, grubs, etc. The kernels should be planted in "check-rows," two and a half or three feet apart, and six to eight kernels in each hill; then, at the expiration of three or four weeks the hills should be thinned out—always removing

Digitized by Google

the least vigorous plants, until three or four only are left in each hill. Bear in mind the necessity of closer planting than is usual, to give you a full crop of corn. While five feet square will give about 1,700 hills, four feet each way will 2,700, and three and a half feet each way, more than 8,700 hills. With manure enough and proper working, this number will grow as well without firing and burning as that first named.

The after culture of corn is simple, but nevertheless indispensable. But you must not put off working it until July. You can not go with plow or cultivator into corn six to eight feet high—the roots branching through every inch of the soil, without doing it irreparable damage.

The grand axioms in corn-raising are—good ground, well prepared, early and careful planting; early cultivation, and hoeing; destruction of all weeds, the summer through. If prompt and energetic action is important and necessary anywhere, it is most emphatically so in a corn-field.

Corn, being the chief summer crop, all other work should be got off our hands, that this may be put into the ground as early as the season will permit, and in the best possible condition. It is certainly among the most important considerations to get the crop started early, and that it have a vigorous, rapid, early growth. If planted late, and it is tardy in coming on at first, the season must prove remarkably and unusually favorable to expect even a middling yield. True, cases may be cited where good crops were obtained from late planting and loose culture; but who is willing to take such cases as governing rules in his general practice?

One plowing is all the cultivation usually given to corn-ground before planting, the seed being planted directly on the furrows; but it can not be disputed, that, excepting our rich, alluvial bottom lands, more working of the soil for this crop would result in a much more rapid growth and early maturity; since the finer the tilth, the more readily do the organs of the plant find their appropriate food. One or two workings, with a two-horse cultivator, after plowing, would prove an amply paying operation, I think, on all soils, except those above noted, which, having been formed by gentle, river deposits, are more thoroughly commingled and divided than can be done by my processes of culture.

Those who plant on greensward will be likely to have trouble with the cut-worm. To get rid of these insects, there appears to be but one effectual means, and that is, killing them outright, by passing over the field very early in the morning, armed with sharp sticks, to oust them from their hiding-places. It is worse than a waste of time to apply any nostrums, however strongly advised and recommended. Plowing

Digitized by Google

greensward, in August, the year previous, will insure safety against the cut-worm. The experiment was carefully tried in the same field, and though one to three worms were found in the last hill on the newly plowed ground, not a single one was seen on that portion plowed the previous year.

My opinion has been asked in regard to the expediency of cultivating Indian corn entirely by the hand hoe, which formerly was the only culture it received—save an apology for plowing. Good crops have been obtained by this mode, on soils that remain sufficiently loose through the season. Whether it is the most *profitable* way even on that kind of soil, is a question. The argument in favor of it is, that the implements usually drawn by a horse, cut off and mutilate the roots of the corn. This is not necessarily so. It is very true that the cultivator or plow may mutilate a few roots, but they readily form new spongioles (see page 142), and are not in consequence retarded in growth. By stirring the soil new surfaces and new particles of matter are presented to the root from which to elaborate nutriment. (See pages 420 to 424). For the same reason, if a harrow is drawn across a wheat field in spring time, when the soil is not wet, although many plants are mutilated, yet the remainder are more thrifty, stool better, and the crop is invariably larger than if the harrow had been withheld.

The principal cultivation of Indian corn should be while it is comparatively small. At this stage the roots have not extended themselves far, and implements may penetrate the ground as deeply as desired without doing the growing plants any harm. As the crop grows, the implements which run deeply should be kept farther down from the stalks, and the use of them finally discontinued altogether. If the space between the rows has been properly cultivated, weeds will not grow much after the corn is so large as to shade all the ground. The little horse plow must not be wholly laid aside to make way for the cultivator. For in many cases the plow is best. When the soil lies heavy the little plow leaves it lighter than a little harrow or cultivator. The plow should run as close as possible to the corn and turn the earth away from it. Next time the earth may be turned toward the corn—and the third time hoeing the cultivator may be used, when the holder fears that the plow would cut his corn roots. The steel tooth cultivator is best, as the teeth may be kept bright and clean.

But corn is cultivated to a great extent in the country, on soils which tend to more compactness than is favorable to the crop. Here some means must be devised to counteract this tendency. In many cases, especially if heavy rains are followed by dry weather, the fore part of the season, some implement must be used that will penetrate

Digitized by Google

nearly to the depth to which the ground was first plowed, in order to prevent baking, and to afford a deep, friable bed for the corn roots. To accomplish this object by hand hoeing would be almost an impossibility, to say nothing of the expense.

On the whole, I think the great aim should be to substitute horse and ox labor for manual labor, as far as possible, in the cultivation of Indian corn and other crops. The expensiveness of hand labor forms an obstacle to corn culture. By the use of proper tools and by proper skill, the crop might be made to do better than it now generally does, and with considerable saving of expense. We have repeatedly seen fields of corn well cultivated, and with scarcely a weed to be seen, that never had a hand hoe in them. It is true that the larger and stronger stalks of the corn grown at the South render it more easy to keep down the weeds without injury to the corn than it would be with our varieties; but even here the thing could be done so far as to greatly lessen the use of the hand hoe.

It is not necessary—probably not advantageous—to deeply cultivate between the rows of corn on very light soils. It is on such that hand-hoeing may answer; but tools might be used with a horse that would merely scrape the surface, if that only was desired. The common plow is not the best thing to cultivate corn with. On light land it disturbs the soil too much—that is the small portion of it which is touched at all—it is left too much in ridges and hollows. *Level* cultivation, which is best on loose, dry soils, can not be had with it. On tenacious soils, the plow even presses the under portion more closely than it was before. Cultivators, grubbers, horse-hoes, etc., are preferable to the common plow in cultivating growing crops.

STATEMENT *of the number of acres planted in Corn in* 1857 *and* 1858 *in Ohio, also the number of bushels gathered in each of these years.*

COUNTIES.	1857.		1858.	
	CORN.		CORN.	
	Acres.	Bushels.	Acres.	Bushels.
Adams	33,896	1,078,956	30,507	825,137
Allen	29,841	679,744	12,781	315,799
Ashland	18,856	696,467	17,495	545,970
Ashtabula	9,620	327,591	11,802	457,070
Athens	23,164	854,324	19,214	418,899
Auglaize	17,847	537,460	11,300	222,947

Digitized by Google

COUNTIES.	1857. CORN.		1858. CORN.	
	Acres.	Bushels.	Acres.	Bushels.
Belmont	82,384	1,330,408	25,890	676,479
Brown	89,188	1,350,769	35,350	1,001,180
Butler	56,388	2,696,597	49,848	1,448,846
Carroll	11,954	401,637	9,980	241,366
Champaign	37,880	1,475,670	30,638	962,809
Clark	80,914	1,222,009	23,670	764,756
Clermont	88,569	1,425,540	34,240	920,761
Clinton	88,980	1,402,003	38,484	1,041,164
Columbiana	16,453	503,856	13,795	406,662
Coshocton	88,906	1,442,972	33,913	1,013,446
Crawford	24,800	861,039	19,549	554,300
Cuyahoga	10,512	869,194	10,149	361,458
Darke	33,331	1,174,368	23,912	455,300
Defiance	9,458	304,312	6,182	153,295
Delaware	34,639	1,445,316	25,756	685,090
Erie	20,439	601,713	15,844	488,290
Fairfield	49,630	1,858,862	39,464	1,147,935
Fayette	48,611	2,257,752	48,564	1,232,669
Franklin	62,934	2,665,661	50,570	1,456,775
Fulton	9,308	276,798	6,614	141,822
Gallia	19,480	645,468	17,330	393,359
Geauga	6,687	217,144	6,082	229,348
Greene	37,471	1,592,590	30,827	1,083,990
Guernsey	22,651	746,861	17,427	379,410
Hamilton	31,928	1,172,831	26,857	822,530
Hancock	22,290	594,561	17,514	442,428
Hardin	16,254	512,158	11,293	261,852
Harrison	17,461	702,270	14,244	372,096
Henry	6,120	178,573	4,601	110,159
Highland	53,554	2,022,218	48,998	1,561,199
Hocking	16,865	560,828	14,583	338,612
Holmes	18,214	572,319	16,385	401,782
Huron	31,767	897,100	22,566	547,251
Jackson	19,000	533,841	15,975	361,432
Jefferson	15,562	583,940	12,828	292,259
Knox	33 640	1,216,205	30.290	976,396
Lake	6,437	238,348	6,592	252,990
Lawrence	17,393	553,244	16,342	390,754
Licking	48,156	1,944,390	46,810	1,476,061
Logan	29,223	1,081,369	24,568	607,674
Lorain	11,977	410,705	9,913	285,468
Lucas	6,131	198,444	4,780	128,613
Madison	36,410	1,541,601	26,297	704,946

Digitized by Google

COUNTIES.	1857.		1858.	
	CORN.		CORN.	
	Acres.	Bushels.	Acres.	Bushels.
Mahoning	12,265	422,876	10,477	397,687
Marion	84,074	1,365,109	24,854	626,270
Medina	14,929	743,624	11,978	485,830
Meigs	15,285	547,689	13,091	329,582
Mercer	17,251	543,845	9,294	148,926
Miami	42,117	1,631,301	28,430	752,016
Monroe	20,034	598,384	16,600	309,884
Montgomery	37,306	1,569,125	22,854	655,299
Morgan	21,645	842,857	18,176	515,080
Morrow	23,531	817,874	16,832	448,897
Muskingum	89,512	1,469,595	32,641	1,001,408
Noble	22,612	793,998	20,375	558,788
Ottawa	3,685	120,459	3,274	85,517
Paulding	3,883	116,674	2,177	44,770
Perry	21,054	674,266	18,957	549,636
Pickaway	72,188	3,409,177	49,940	1,392,296
Pike	27,715	1,050,976	21,701	612,029
Portage	11,371	620,088	9,620	418,669
Preble	89,210	1,420,901	31,615	890,796
Putnam	17,089	467,610	11,158	209,041
Richland	25,216	746,842	21,098	613,249
Ross	74,114	3,897,188	71,051	2,011,998
Sandusky	16,991	408,991	18,036	360,292
Scioto	24,767	949,069	18,014	530,125
Seneca	27,271	747,423	21,847	478,828
Shelby	21,680	695,603	10,939	248,838
Stark	21,791	751,120	27,477	594,637
Summit	11,142	307,979	10,611	420,029
Trumbull	12,294	439,247	10,169	401,493
Tuscarawas	23,649	948,521	20,577	506,091
Union	32,413	1,203,610	21,451	480,314
Van Wert	9,434	291,686	5,732	82,008
Vinton	14,587	450,898	11,350	254,985
Warren	43,206	1,884,777	33,992	989,687
Washington	22,646	719,561	20,596	533,206
Wayne	24,685	824,871	21,939	730,098
Williams	11,241	345,440	6,528	142,266
Wood	14,462	388,487	10,294	210,076
Wyandotte	21,389	783,530	16,886	423,639
Total	2,254,424	82,555,186	1,834,138	50,863,382

Digitized by Google

	No. of Acres.	No. of Bushels.
Corn crop of 1850 was.....	1,537,947	56,619,608
" " 1851 "	1,664,427	61,171,282
" " 1852 "	1,730,188	58,165,517
" " 1853 "	1,836,498	73,436,090
" " 1854 "	1,972,337	52,171,551
" " 1855 "	2,205,282	87,587,434
" " 1856 "	2,084,893	57,802,515

The several varieties of corn cultivated in the State, may be classified into *soft* and *hard*, the latter including that with round and flinty grains, almost transparent, and very hard—rarely whitish or thickened on the outer extremity of the grain, and never dented.

The soft corn is less hard than that which is classified as hard, although not always soft in the common meaning of the term. All the gourdseeds and dent varieties belong to this class, with grains more or less long, always whitish at the end, and more or less dented or pointed. Also corn with short, round grains, that readily break under the nail.

Each of these classes may be subdivided according to color, into *white*, and *yellow or colored*.

Experience establishes the fact, that the flour of the hard, or flinty corns is much less liable to become musty, or to "*sour*" than that of the soft, white, starchy varieties.

There are two original varieties of the flint corn, viz.: the white and the yellow, which, by being crossed on other varieties, have produced an extensive family of hybrids, all of which partake, in a greater or less degree of their progenitors. The flint varieties are more hardy than the soft ones, yield less starch, but are much better adapted for family use, and are less liable to spoil in shipping, either in grain or ground, while they are at the same time less valuable for stock than the soft varieties.

The following is a brief statement of the varieties cultivated in the State, viz.:

Early White.—It matures, in Clark county, Ohio, if planted by the first of June—medium fodder, rather small cob of red and white color, grains dented, sound, and good weight. Each stalk bears one or two ears, and each ear twelve to sixteen rows. It is of medium size, white color, very early, and is a soft variety.

Early Adams.—This corn is considered by some persons, very desirable, while by others it is regarded as unfit for table use, and not as useful for the farm as the Early White. The grains are firm, sound, dented, flinty, and rather heavy. Each stalk bears one or two ears, and each ear from

Digitized by Google

ten to fourteen rows. It is of rather small size, white color, rather early, and is a soft variety.

Peabody's Prolific.—Some persons consider this corn a humbug. Dr. Warder, however, says of it, "This new variety from the South, closely resembles Early Adams, in many particulars. The ears are of a medium size, fodder large, under favorable circumstances prolific—promises well." Each stalk bears two or more ears, and each ear ten to fourteen rows. It is of medium size, clear white color, neither early nor late, and is a soft variety.

White Gourdseed.—This old variety is a favorite kind for feeding in the ear, on account of its softness, although it is inconvenient for an ox to masticate between his grinders, in consequence of its large size. The grains are of medium weight, and very long; the cob is large, but not always sound, and each stalk bears one ear, with sixteen to twenty-four rows. It is short and thick, a dull white color, neither early nor late, and is a soft variety.

Bayou.—This grows quite tall, and is very thrifty, and is much grown in the Miami bottom. The grains are large, dented and heavy; the cob is large, but not always sound, and the husk coarse, and tightly inclosing the ear; the stalk bears one or two ears, and each ear twelve to fourteen rows. It is of large size, dull white color, late, and is a soft variety.

Hackberry White.—This variety, like the Yellow Hackberry, appears to be a cross or hybrid, between the Gourdseed and Dent varieties. The cob is white and red, and scarcely medium size, and the grains are narrow, pointed, medium size, good weight, and white.

The stalk bears one compact and heavy ear, with twelve to sixteen rows, and in some instances as high as sixteen to twenty-two rows. This variety shells very readily, and one hundred and twenty-three bushels have been raised on an acre. It is neither early nor late, and is a soft variety.

Common White.—This is much grown on hill farms, and is a great favorite for bread and stock. Each stalk bears one or two ears, and each ear ten to fourteen rows, and is medium size, dull white color, rather early, and a soft variety.

Speckled White.—This is a curious mixture of red, yellow and white corn, of Gourdseed and Dent varieties. Some of the grains, and some of the ears are speckled, others are pure white, and still others are all red. The grains are long, sound, often pointed like hackberry, and are beautiful in the hand, and will make very good meal. The stalk bears one ear, with twelve to sixteen rows; is of medium size; white, red, or yellow color; and neither early nor late, and is a soft variety.

Digitized by Google

Wyandotte.—This curiosity is unworthy of culture, on account of its lightness and lateness. It has many suckers, and all produce tassels and ears, and a single grain is sufficient for a hill. It has been grown in very few places only, and has not been favorably received in those places where it has been grown. Each stalk bears four to eight ears, and each ear from eight to ten rows. It is of medium size, and white, and is a soft variety.

Flour, or *New York Cheat.*—This corn has credit of being a material of value in the preparation of the fancy brands of Genessee flour, for which the extreme whiteness of its meal well adapts it. For other purposes it is not desirable, as it is neither prolific, sound, nor heavy. Each stalk bears one or two ears, and each ear eight rows. It is medium size, neither early nor late, and is a soft variety.

Tuscarora, or *Early Suchett.*—This is desirable only for an early crop of roasting ears, for the market, and most persons would prefer to wait a fortnight for the Sweet Corns. The grains are large and white, or dull white, and the cob is red and very small. Each stalk bears two ears, and each ear eight rows, and it is a soft variety.

Baden.—This is undoubtedly a Southern variety. Various attempts have been made to grow it, in different portions of the State, but without success. It requires a very long and favorable season to mature it. Each stalk bears two or more ears, and each ear eight to ten rows. It is small sized, and of yellowish or dull white color, and is from Baden, in Germany. It is a soft variety.

New England Sweet Sugar.—This is excellent for table use. If it is ground when very dry, it makes very good but not handsome bread, it being the sweetest of all the varieties of corn. Each stalk bears two ears, and each ear eight rows. It is small, translucent, and neither early nor late, and is a soft variety.

Mammoth Sugar.—This is an improvement in the size of ears. Each stalk bears two ears, and each ear eight rows. It is of medium size, translucent, and neither early nor late, and is a soft variety.

Stowell's Sorghum.—This is a delicious variety, and is deservedly a great favorite with all lovers of roasting ears. It has all the sweetness of the New England, with greater size of ear and depth of kernel, and a larger number of rows. Each stalk bears two ears, and each ear twelve to eighteen rows. It is medium size, translucent, and neither early nor late, and is a soft variety.

Yellow, Blue and Red Sugars are all mere shoots from the New England, and are not desirable. Each stock bears two ears, and each ear eight rows. It is small in size, neither early nor late, and is a soft variety.

Digitized by Google

Wigwam.—This is from the State of New Jersey, and has many points to recommend it to public favor. It is vigorous and productive; fodder, medium to large; the ears are very long and regular; the cob is red and white and small; the grains are dented, heavy and sound, but not so hard as to prevent thorough mastication by cattle, while the size of the ears and small cob enables them to bite off a portion at a time, and submit it to the influence of their grinders. This item may not be appreciated by those who feed meal and slop, but for the "*million*," it is no mean consideration. Horses select this corn from other varieties fed with it, and eat it first. Each stalk bears at least one ear with ten to sixteen rows. It is large in size, and of bright yellow color, neither early nor late, and is a soft variety.

Dent.—This a favorite variety, possessing many good qualities, being a medium between the Gourd-seed and Flint varieties. There are several varieties of the Dent tribe, as the Early, the White and the Yellow. The Early Dent is an eight-rowed, white variety, each stalk bears two ears, and it ripens in about one hundred days. The White Dent has from ten to fourteen rows on each ear, some of the stalks bear two ears, others one only, and it ripens at least ten days later than the Early variety. The Yellow variety has all the characteristics of the White, with the exception of color, it being a bright yellow, but requires ten days longer to mature fully. The Dent family of corn is perhaps more extensively cultivated in Ohio than any other. It yields from sixty to seventy-five bushels per acre. It is medium to large size, and is a soft variety.

Big Yellow.—Cob is rather large, but the grains are not as large as some other sorts. Each stalk bears one ear with twelve to sixteen rows. It is large, dull yellow color, neither early nor late, and is a soft variety.

Maryland Gillou.—Was brought from Maryland many years ago. A specimen of it was sent from Ohio to the "World's Fair" in England, where it took the premium over all others exhibited. This variety is nearly lost by its lateness in the bad seasons. Each stalk bears one ear with twelve to sixteen rows. It is very large, deep yellow, and late, and is a soft variety.

Hackberry.—This variety is grown to a considerable extent in central Ohio. It is a hybrid or cross between the Gourd-seed and Dent varieties, and is very popular. Each stalk bears one ear with twelve to sixteen rows. The grains are long, pointed, generally sound, and are of a dull yellow color, though sometimes speckled grains may be seen. It matures in ordinary seasons, about the first of September, and is of medium size, rough to handle, and is a soft variety.

Bloody Butcher.—This is a hybrid between the Hackberry, Dent and

Digitized by Google

Red, and is considerably grown in the bottoms. It matures about the first of October in the northern portion of the State, and from ten days to two weeks earlier in the southern. Each stalk bears one ear with twelve to sixteen rows, and is of medium to large size, and dull yellow red and striped colors, and is a soft variety.

Pymm.—This variety is from Pennsylvania, and is a very handsome, heavy, large Dent corn. Each stalk bears one or two ears, and each ear twelve to sixteen rows. It is of large size, yellow color, and is neither early nor late, and is a soft variety.

Lee County, Iowa.—This is a variety distributed by the Patent Office, is one of the largest Early varieties, and is valued for replanting or late planting. The grains are sound, firm, large, and of bright yellow color. Each stalk bears one or two ears, and each ear twelve to fourteen rows. It is a soft variety.

Bonem or Bonham. This variety is much grown in the Miami bottoms, where it originated, and is productive, sound, and of good weight. Each stalk bears one or two ears, and each ear twelve to sixteen rows. It is of medium size, chocolate or dull red color, neither early nor late, and is a soft variety.

Master.—Is from Tennessee, and is so distinct as to maintain its character when mixed with other sorts, upon which it leaves its impress, and hence the name it bears. The grains are rather deep, dented, sound, though not heavy. Each stalk produces one or two ears, and each ear ten to twelve rows. It is from medium to large size, dull red color, early, and is a soft variety.

Clinton.—This variety is from J. S. Lecoming, Wilmington, Clinton county, Ohio, and promises well. Each stalk bears one or two ears with twelve to fourteen rows. It is from medium to large size, dark yellow color, early, and is a soft variety.

Gourd-seed or Horse-tooth.—This variety is extensively cultivated in the southern portion of the State. It is a soft variety, ear short, and densely packed with eighteen rows of large white grains, having the summit indented, possibly from the drying of the starch. The indentations make it rough corn to handle.

Bastard Gourd-seed.—Is grown to a considerable extent in central and eastern Ohio. It is productive, not so hard as the flint, nor so rough to handle as the Gourd-seed, and matures rather earlier than the latter. It has yellow, good-sized grains, sixteen rows to the ear, although sometimes ears are found containing eighteen or twenty rows. It is a soft variety.

Sheep-tooth or Small Gourd-seed.—It is a variety of the Hackberry, and is grown in the northern part of the State. Each stalk produces

Digitized by Google

from one to four ears, each with twelve rows of small and dark yellow grains. It ripens from the middle to the last of October, and is a soft variety.

Yellow Gourd-seed.—This is a sixteen rowed variety of yellow corn—in other respects it much resembles the White Gourdseed or Horsetooth, and is a soft variety.

Large White was originally from Tennessee. Each stalk generally produces two ears with twenty rows of white, large-sized grains on each ear. It ripens early.

Ohio.—The stalk not unfrequently bears two ears. It is a yellow, twelve-rowed variety, and ripens about the first of October, in the northern part of the State, where it is cultivated to some extent.

Pennsylvania.—This is a twenty-rowed, reddish variety of corn, introduced several years ago in the northern part of the State, from Chester co., Pa., but it meets with no favor from the fact that it ripens very late, although it has many desirable qualities.

Tree Corn.—Several attempts have been made to introduce this variety, but the great length of time required to mature it has been the obstacle to overcome. It is a yellow variety, each ear having from sixteen to twenty-six rows, and each stalk generally bearing two ears.

White Flint.—This is an excellent, sound and productive variety. Each stalk bears one or two ears, and each ear eight to ten rows. It is large and pure white color, and, under ordinary circumstances, matures during the month of September. This variety was originally from Maryland, weighs sixty pounds per bushel, and is very hard to grind.

Small White Flint.—Fodder small, ears low, husk loose, retaining water and spoiling the grain and cob. It is used for hominy. Each stalk bears two ears, and each ear eight rows. It is medium size, creamy white color, and early.

Early White Flint has the same characteristics as the Small White Flint, color excepted, it being pure white. It is used for hominy, roasting-ears, and bread. Fodder tall.

Arkansas Hominy.—This variety was brought from the South; produces very large fodder, but is too late in ripening to be useful. Each stalk bears two ears, and each ear eight rows. It is medium size, dull white color and hard.

Pink Flint.—Perhaps this is not a distinct variety. It may be Early Adams changed. Each stalk bears two ears, and each ear ten rows. It is of small size, pink color and early.

Mexican Flint.—This beautiful corn was received from the Patent Office, and is productive, sound, and heavy. The very large, firm, white grains characterize it especially for the manufacture of hominy. Each

Digitized by Google

stalk bears two ears, and each ear eight to twelve rows. It is large, white, and early.

White Pop Corn.—This is the prettiest variety of pop corn. There is a great number of very compact small-eared, ten-rowed varieties of corn which are cultivated in gardens, the stalk yielding from two to six ears, and are good for the purpose of "popping."—The smallest are preferred.

Rice Corn is a pearly white, small, but very long grained, twelve-rowed garden corn, each stalk bearing from two to three ears.

Yellow Flint.—This corn is too hard for hogs or cattle. It is heavy, sound, makes good bread, and is valuable for replanting. Each stalk bears two ears, and each ear eight rows. It is large, bright yellow color, and early.

Canada.—This corn has the same characteristics as the Yellow Flint, except that it is small and of a clear pale yellow color.

Dutton is not valuable as a field crop, where Dent corn will ripen. It is small, bright yellow, two ears to the stalk, and eight rows to the ear, and early.

Golden Sioux is one of the original Indian corns. It is quite small, of clear yellow color, very early, two ears to the stalk, and eight rows to the ear.

King Philip was introduced several years since from the Eastern States, but is not held in high estimation except in a few isolated localities. A very intelligent farmer from Guernsey Co., writes:—"The King Philip is the king of humbugs; it is so eager for maturity that no matter when planted, nor in what kind of soil, it begins to tassel when knee high regardless of the season, and to die as soon as tasseled, making little grain and less fodder. It is represented to yield one hundred bushels per acre—it would still be a great exaggeration, giving the King the benefit of his roots, stalk, husks, blades, and crown, in the measure." It is most generally used for replanting where later varieties have suffered from frost or late spring.

The ear contains eight rows, but has been improved to twelve rows; the grain is of moderate size and deep orange color; ears long, slender, with little variation in thickness from top to base; and two ears usually grow to the stalk.

Omaha.—This variety ripens far north in September. Its beautiful large blue grains yield a very white meal. It is very early, of deep blue color; two ears to the stalk, and eight rows to the ear.

Purple Wyandotte is heavy, very hard, and very prolific. It is of medium size; purple color; and each stalk bears five ears, and each ear eight rows.

Digitized by Google

Red Pop Corn is very prolific, very small, very red, and is early. Each stalk bears five to nine ears, and each ear eight to ten rows.

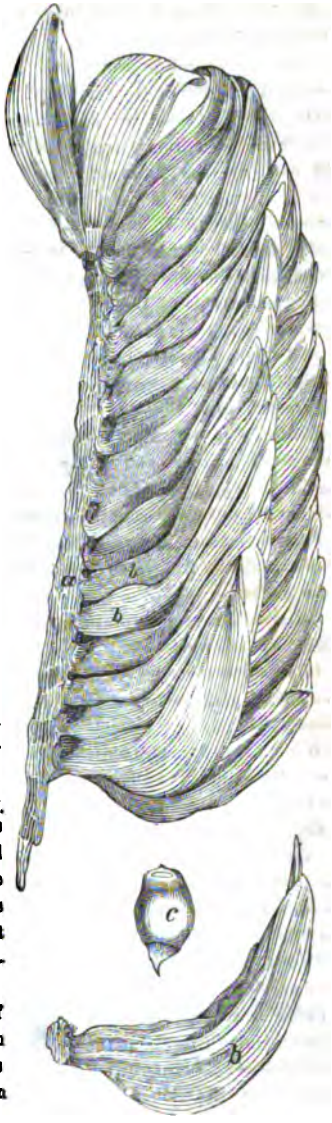
Yellow Pop Corn is small, of bright yellow color, and neither early nor late. Each stalk bears from four to six ears, and each ear ten to twelve rows.

Mixed Pop Corn.—Thirty-two ears were produced from one grain of this variety; every joint throwing an ear or a branch of ears. It is very small; blue, yellow, and white; six to twelve ears grow upon the stalk, and ten to twelve rows upon the ear.

New York is grown to a considerable extent in the northern portion of the State. Each stalk bears two to four ears, and each ear eight rows. Under ordinary circumstances, it ripens about the middle of August. There are several varieties, differing in color only from a pure white to yellow, and even dark orange, like the King Philip.

Wabash was introduced as much as eighteen years ago into south-eastern Ohio. It is a white variety; each ear having fourteen to twenty-four rows of large grains; it has also a large cob, but the shelled corn weighs from fifty-eight to sixty pounds per bushel, and makes an excellent quality of bread. It ripens during the month of September.

Lady Washington has ten rows of medium sized grains, of a whitish shaded with purple color. It ripens early, and promises to be quite an acquisition.



Digitized by Google

Yankee.—There is an eighteen-rowed, yellow variety of this name, cultivated in Summit county, Ohio; each stalk bearing four ears. "It matures early, and is pretty well liked as an upland corn; it has small ears, and the grains are very hard."

Oregon, California, or *Wild Corn.* Samples of this variety have been introduced from Oregon, California, Mexico, and South America. The cob (*a*) (see Plate on preceding page) does not exceed half an inch in diameter; is very pithy; the grains are each enveloped in a separate husk (*b b*), and attached to the cob. The grain (*c*) is very flinty, dented, rather ovate, sides convex, and pointed at its place of insertion in the cob. It is grown as a curiosity only.

Virginia.—This is a very late light-yellow variety; has from twelve to sixteen rows; is considerably cultivated in central and eastern Ohio.

Red Cob is a twelve-rowed yellow corn; ripens during the first week in September; the grains are medium sized, and the cob, as the name indicates, is red.

Kentucky is a twelve-rowed white corn; matures during the latter part of September, and is highly spoken of. It weighs eight to ten pounds heavier than yellow corn generally; of course, it yields better and is said to stand drought better than the yellow.

Illinois Brown is a twelve-rowed brown corn; ripens about the middle of September; the grains are medium sized, of a dark brownish color, each stalk bearing from one to three good sized ears. It was formerly in better repute than at present, from the fact that it rapidly deteriorates.

Trumbo is a variety cultivated to some extent in south-eastern Ohio. It is a fourteen-rowed yellow variety; has generally one to two long and sound ears to the stalk. It matures early, and stands in good repute.

White Cap is a sixteen-rowed yellow variety; matures about two weeks later than the Dent. The stalks are two to three feet higher than the Dent, and yield from sixty to eighty bushels per acre.

Cregar.—This is a brown hybrid variety, possibly between the Illinois Brown and King Philip. There are from sixteen to twenty rows on each ear, and sometimes two ears to the stalk; it deteriorates by culture, and does not ripen until the middle of October or first of November,—entirely too late for the climate of Ohio.

Tuscarawas is a ten-rowed white corn, ripening about the first of October; it is cultivated to a considerable extent in south-eastern Ohio.

Calico is a fourteen-rowed variety; the grains are yellow, with red stripes; and ripens about the first of October.

Hominy is an eight-rowed white variety; large grain; one ear to the stalk; ripens in October in northern Ohio; and is much used for hominy.

Digitized by Google

Scott's Striped Corn.—This variety was produced by Mr. S. H. Scott, of Morgan county, by crossing a variety of the Yellow Dent having twenty rows with a yellow red eight-rowed corn. Scott's Corn is reddish, with a yellow stripe; sixteen to eighteen rows to the ear, and two ears to the stalk; it ripens about the 25th of August. Mr. S. says: "I found this hybrid to be of better quality than either of the originals—is better adapted to the climate—yields eighty to ninety bushels per acre and there are nine pounds of cob to every fifty-six pounds of corn."

The following is a condensed statement of the replies from County Agricultural Societies to questions propounded on the annual circular by the Corresponding Secretary of the Ohio State Board of Agriculture:

CORN.

COUNTIES.	1. How late was the latest corn planted in your county? 2. Did it mature?	What were the consequences to cattle and hogs, fed on the unripe corn of last year?	What varieties succeeded best?
Adams	.....	Bad, especially for horses.	White yellow flint.
Ashland	20 June.	.....	Hackberry and Gourd seed.
Ashtabula	15 to 20 June.	.....	Red-cob, gourd seed, King Phillip, on good soil, yields most.
Athens	3d July. Matured well on bottom lands.	Cattle some. Hogs none.	Yellow gourd seed.
Belmont	9th of June.	No bad consequences. Did not fatten stock well.	Yellow gourd seed best, white flint next.
Brown	June. 2. Yes.	Bad.	Red Cob Yellow
Butler	Some varieties of flint were planted latter part of June.	None.	
Carrol	12th to 15th June.	.....	Yellow gourd seed.
Champaign	1st of July.	Would not fatten.	Gourd seed and flint.
Crawford	6th July. 2. Yes.	.....	.....
Cuyahoga	25th of June.	Looseness of the bowels.	Gourd seed.
Darke	22d of June.	None.	Small yellow.
Defiance	1 to 10 July. 2. Yes.	None.	Yellow flint.
Delaware	7th of July. 2. Yes	None.	Common yellow Dent, York State and Michigan.

Digitized by Google

COUNTIES.	1. How late was the latest corn planted in your county? 2. Did it mature?	What were the consequences to cattle and hogs, fed on the unripe corn of last year?	What varieties succeeded best?
Fairfield.....	10th June. 2. Yes.	None.	Yellow flint.
Fayette.....	7th of July.	Did not fatten well.	Fair crop in some places, damaged by heavy rains in others.
Gallia.....	24th of June.	Stock killed by unripe corn.	
Guernsey.....	1st July. 2. Did not all mature.	No.	Gourd seed, hackberry, yellow flint.
Hamilton.....	.....	.....	King Philip tried with success.
Hancock.....	1st July. 2. Matured well.	Slightly injurious to stock.	Yellow and white gourd seed.
Hardin.....	25th June. 2. Most matured.	Did not fatten well.	Yellow.
Highland.....	22d of June.	No bad effect.	Common yellow and white.
Hocking.....	25th June. 2. Matured.	Did not fatten well.	Small yellow.
Huron.....	25th June. 2. Matured.	No bad consequences.	Hackberry.
Jackson.....	5th July. 2. Matured.	Fattened hogs slowly.	Small white flint and large yellow. (See original.)
Knox.....	4th July. 2. Not all.	Did not fatten well.	.....
Lake.....	2d July. 2. Yes.	None.	Red cob gourd seed.
Lawrence.....	25th June. 2. Yes.	None.	Large yellow and white.
Logan.....	25 May. 2. Yes.	Fattened slowly.	Yellow gourd seed.
Lorain.....	10 July. 2. Yes.		Alabama White, Hackberry small yellow gourd.
Lucas.....	27 June. 2. Yes.	They kept fat.	Yellow Dent and King Philip.
Madison.....	1 July. 2. No.	But few cases of serious consequence	Every kind known in Scioto Valley.
Marion.....	4 July. 2. Not all.	Did not fatten well.	.....
Medina.....	22 June. 2. Yes.		Gourd seed and Flint.
Meigs.....	10 June. 2. Yes.	.....	Yellow hackberry.
Mercer.....	15 July. 2. Yes 7-9	Fattened slowly.	.....
Miami.....	29 June. Yes, ¾.	.....	Yellow brown and striped.
Monroe.....	15 June. 2. Yes.	.....	.....
Montgomery...	25 June. 2. Yes.	Took more to fatten	Common yellow.

Digitized by Google

COUNTIES.	1. How late was the latest corn planted in your county? 2. Did it mature?	What were the consequences to cattle and hogs, fed on the unripe corn of last year?	What varieties succeeded best?
Morgan.....	10 July. 2. Yes.	Almost worthless for stock.	Common yellow.
Morrow.....	25 June. 2. Yes.	Slow growth.	.....
Muskingum...	16 June. 2. Yes.	.....	.....
Ottowa.....	1 July. 2 Nearly all	.....	.....
Portage.....	25 June. 2. Yes.	.....	Red Cob, gourd seed, King Philip
Preble.....	15 June. 2. Yes.	Done very well.	.....
Putnam.....	8 July. 2. Not all.	" " "	.....
Richland.....	10 July. 2. No.	Good for cattle, not for hogs.	.....
Ross.....	4 July. Did not mature. 1st of July, Yes.	.....	Yellow Ripley and Kentucky White.
Sandusky	20 June. 2. Yes.	We have heard of some Stock being killed.	Gourd seed.
Scioto.....	4 July. 2. Yes.	Not injurious, more to fatten.	.....
Seneca	25 June. ½ matured	More to fatten.	Small yellow.
Shelby.....	1 June. 2. Yes.	Not injurious.	.....
Stark.....	6 June. 2. Yes.	Did not thrive well	Gourd seed and King Philip.
Summit.....	16 June. Matured. July 5. Did not mature.	" " "	Yellow flint.
Tuscarawas ...	20 June. 2. Matured well.	Not nutritious.	Robinson and Quand's yellow.
Union.	3 July. 2. No.	.....	Common yellow and white.
Van Wert.....	28 June. 2. Yes.	None injured by it.	Yellow gourd seed and King Philip.
Warren	10 June. 2. Yes.	Fattened hogs well.	.....
Wayne.....	10 June and later. 2. Yes.	.....	Large quantity of seed brought from Pennsylvania and Illinois; the Penn. the best.
Williams.....	5 July. 2. Yes.	.....	Hackberry, Yellow Dent, and King Philip.
Wood.....	20 June. 2. Not all.	.....	Yellow gourd seed
Wyandot.....	4 July. 2. Yes.	No deleterious effects.	Common yellow.

Digitized by Google

PLATE I.

Digitized by Google

PLATE I.—PAGE 92.

EXPLANATION.—A *Ægilops ovata*, *b*, producing *Æ. triticoides c*; *a*, the original ear from which they proceeded. B, spikelet of Æ ovata with each glume bearing four awns. D, spikelet of Æ triticoides forcibly opened; its two glumes each with 2 unequal awns, a pair of sessile florets and a stalked floret in the middle. E, floret of Æ triticoides forced open with two valves or paleæ, of which one has an awn and a fragment. F, floret of Æ ovata forced open, with two valves or paleæ, one of which has two awns.

Digitized by Google

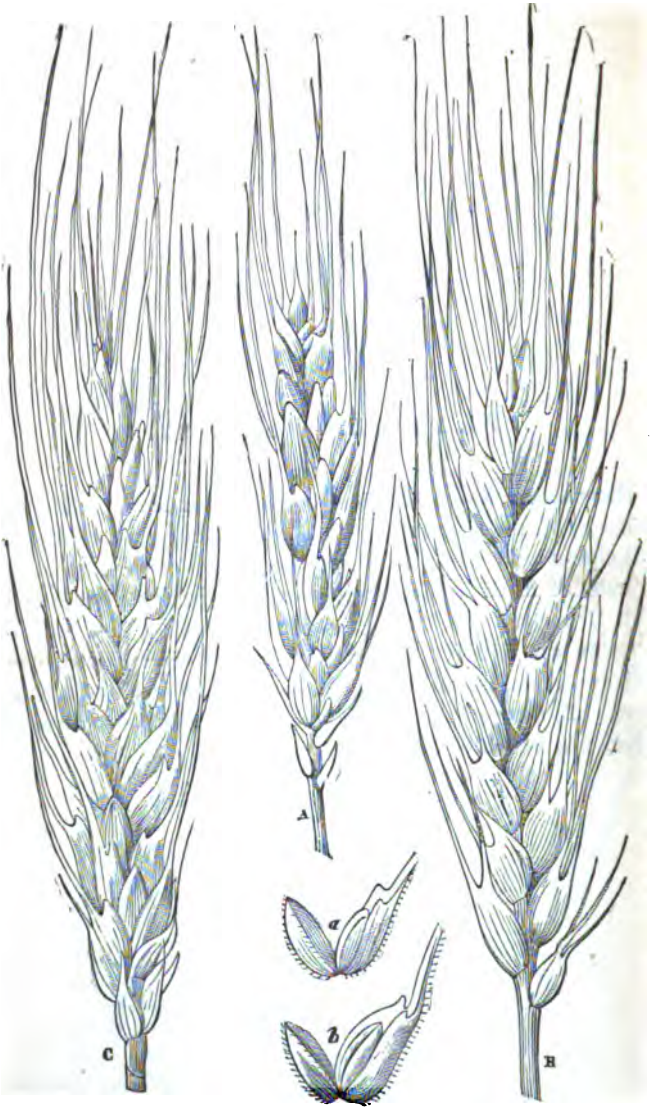


PLATE II.

Digitized by Google

PLATE II.—PAGE 99.

A. Ear of 1840, natural size; *a*, floret and kernel magnified.
B. Ear of 1839, natural size.
C. Ear of 1841, natural size; *b*, floret and kernel magnified.

Digitized by Google

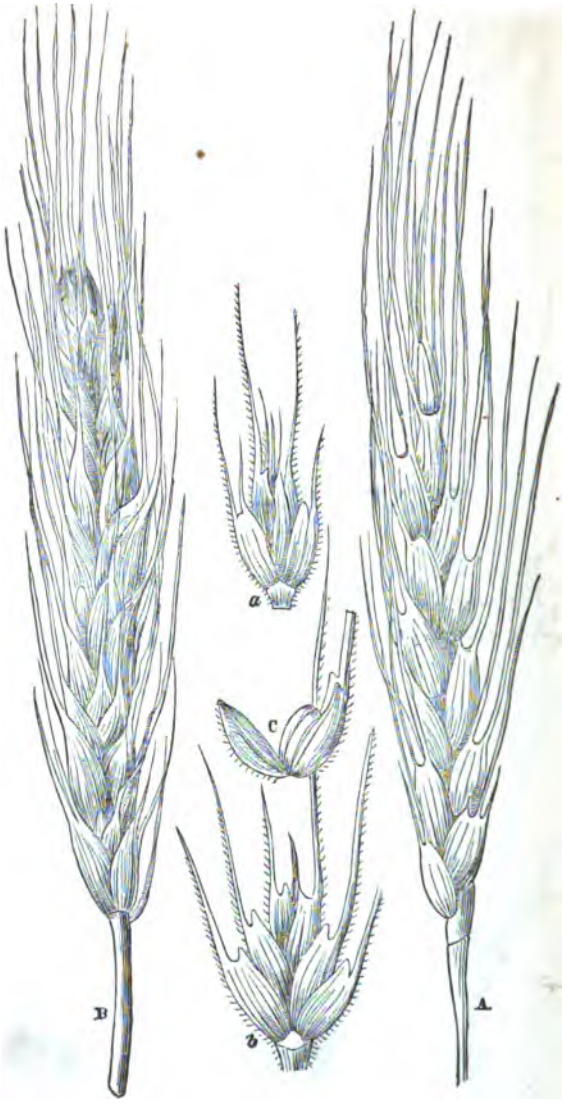


PLATE III.

Digitized by Google

PLATE III.

A. Ear of 1842, natural size; *a*, spikelet somewhat enlarged.

B Ear of 1844, natural size; *b*, spikelet enlarged.

C. A floret with fruit also magnified.

Digitized by Google

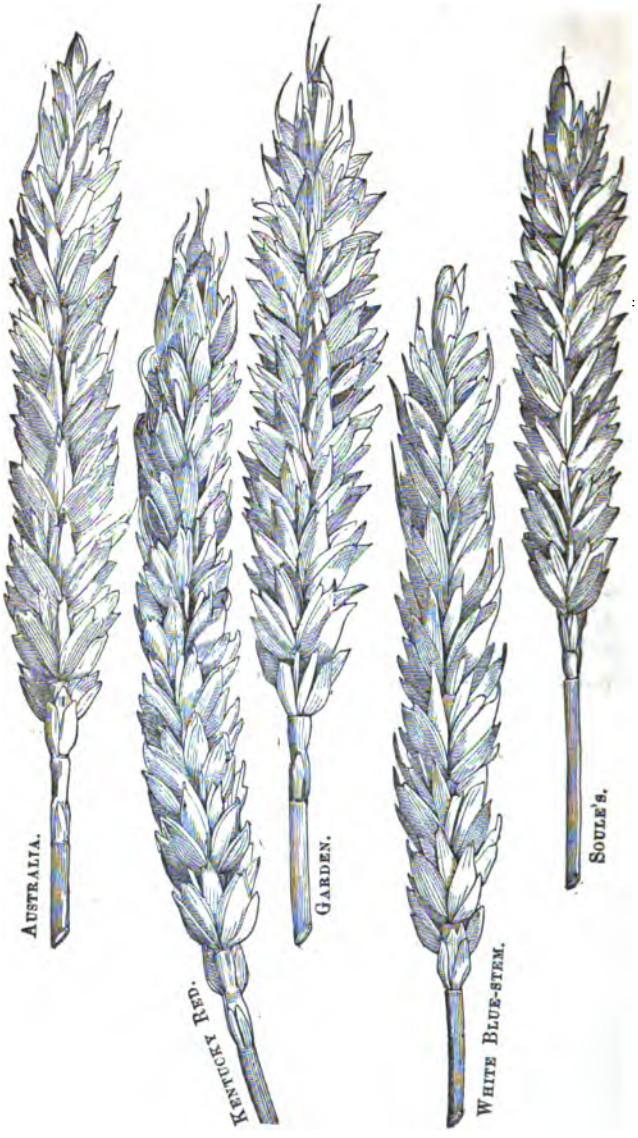


PLATE IV.

Digitized by Google

PLATE IV.

Australian Wheat, - - - - -	Page 525
Garden Wheat, - - - - -	" 528
Kentucky Red, - - - - - -	" 526
White Blue-stem, - - - - -	" 538
Soule's, - - - - - - -	" 548

Digitized by Google

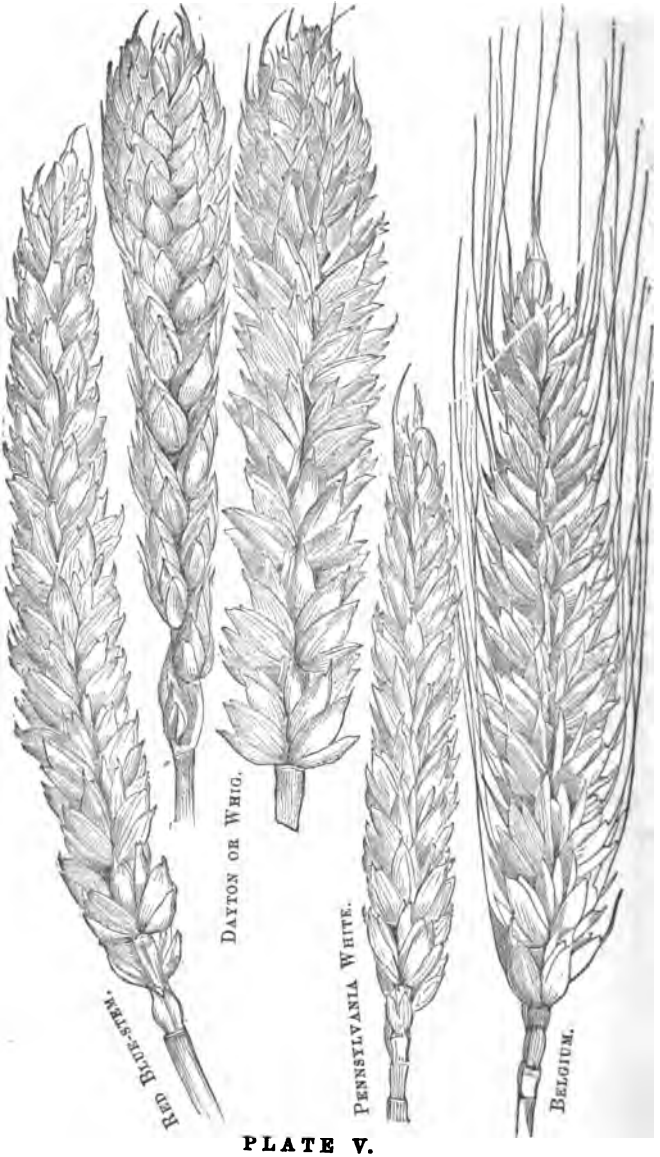


PLATE V.

Digitized by Google

PLATE V.

BELGIAN.—The description of this variety was inadvertently omitted in the text. It is a red bearded winter wheat of the Mediterranean family, and very much resembles the Golden Chaff (page 515). The straw and head are light yellow when ripe; the grain a fair amber color, and much plumper than the Mediterranean. There are from eight to twelve breasts on each side, each breast containing four grains; the beards are very long, and when ripe spread very much. It ripens with the Mediterranean, but should be cut before fully ripe, as it sheds its grains more readily than any variety I have ever seen. It is a vigorous grower, resists midge and rust, and yields better than the Mediterranean. It is grown in Clermont county.

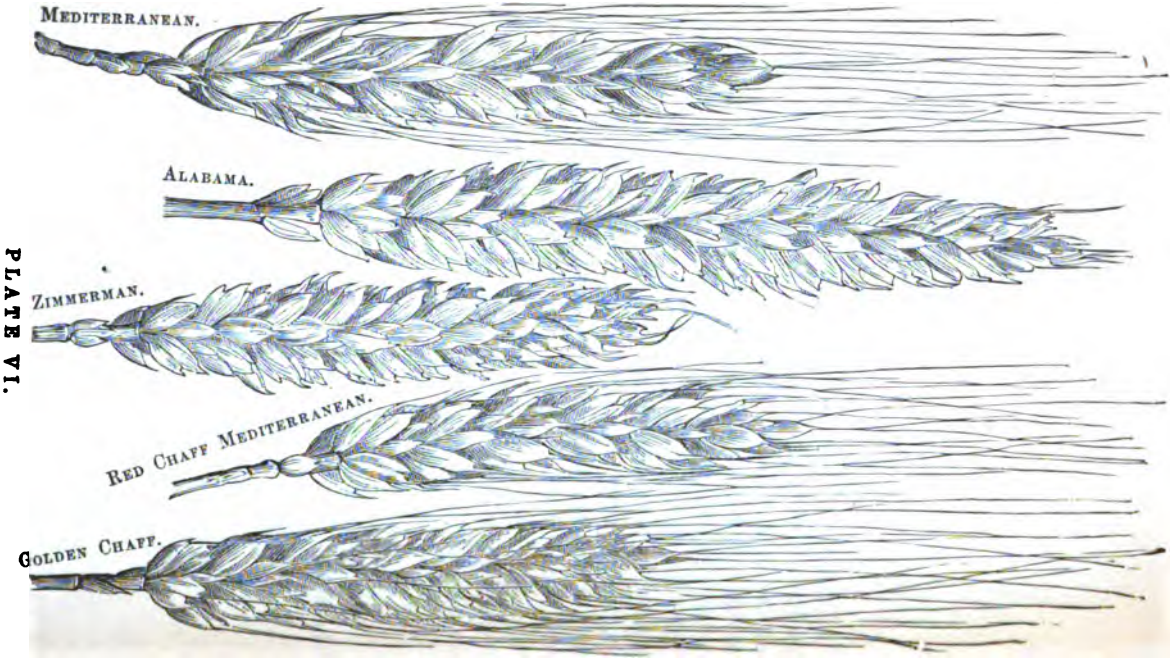
Red Blue Stem, - - - - - - Page 525
Dayton or Whig, - - - - - " 527

☞ The cut represents both a side and a lateral view of the head.

Pennsylvania White, - - - - Page 550

Digitized by Google

PLATE VI.



Digitized by Google

PLATE VI.

Mediterranean, - - - - -	Page 516
Alabama, - - - - -	" 537
Zimmerman, - - - - -	" 532
Red Chaff Mediterranean, - -	" 518
Golden Chaff, - - - - -	" 515

Digitized by Google

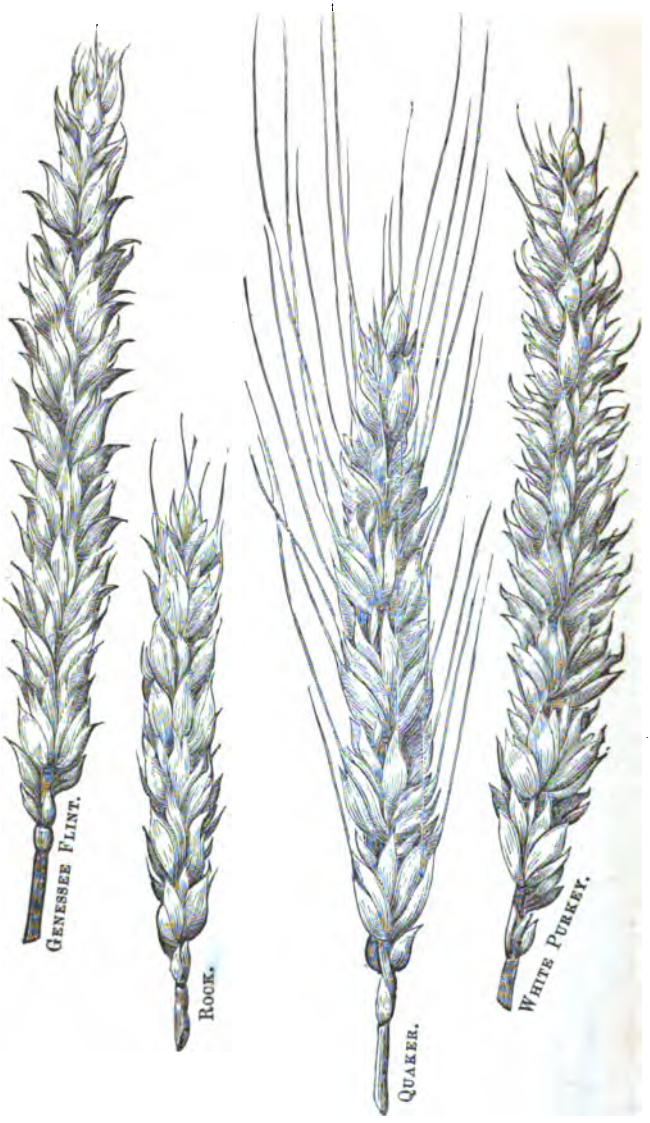


PLATE VII.

Digitized by Google

PLATE VII.

Genessee Flint, - - - - - Page 543
Rock, - - - - - - - " 523
Quaker, - - - - - - - " 520
Purkey, - - - - - - - " 546

Digitized by Google

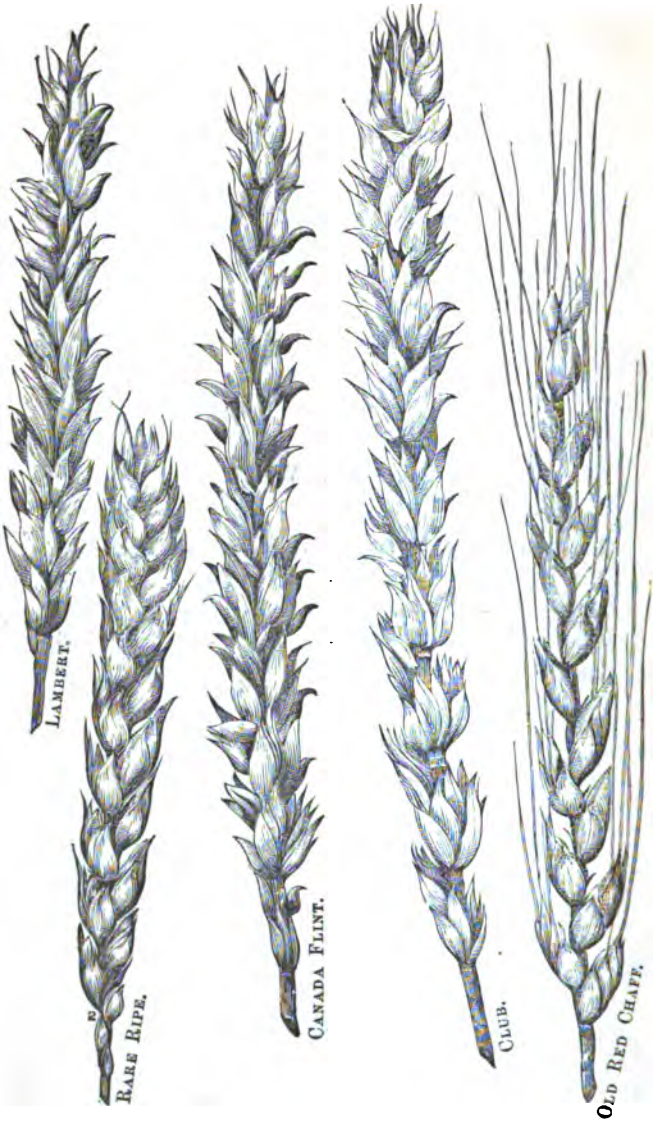


PLATE VIII.

Digitized by Google

PLATE VIII.

Lambert, - - - - - - -	Page 545
Early Ripe, - - - - - -	" 542
Canada Flint, - - - - - -	" 540
Club, - - - - - - -	" 540
Old Red Chaff, - - - - - -	" 518

Digitized by Google

Digitized by Google

INDEX.

Page.

Arable land in Ohio ... 309
Anther of wheat (ill.) ... 27
Ægilops, varieties of ... 92
" description of ... 96
" Fabre's experiment with ... 98
" produces wheat ... 101
Ashes of plants, analysis of ... 237
Ammonia, properties of ... 170
" contained in soil ... 171
Apocrenic acid, composition of ... 175
Ammonia, use of in plants ... 202
" necessity of ... 203
" and carbonic acid ... 205
Alumina, composition of ... 155
" fruit-forming substance ... 219

Barley, history of ... 49
Black Sea wheat, analyses of ... 113–115
Barley, experiments with ... 225
" experiments with ... 234
Boussingault's experiments ... 238
Buckwheat, experiments with ... 235

Classification in animal kingdom ... 18
" in vegetable kingdom ... 18
" in mineral kingdom ... 19
Cattle and horses, no diverse origin of ... 24
Chaff, analysis of ... 116
Carbon, properties of ... 164
Carbonic acid, effect of in soil ... 192
Carbon obtained from the soil ... 193
" in plants, Henfrey's theory of ... 194
" " Liebig's theory of ... 193–5
Carbonic acid and ammonia ... 205
" " not derived from the air ... 208
Caird's statement of Illinois soils ... 302
Cereals and grasses, history of ... 36
" " geographical distribution of ... 39
" what ones most in use ... 41

Digitized by Google

Page.

Cereals, varieties of ... 42
Chess, is it derived from wheat ... 69
Cellulose ... 125
Cell production ... 137
Crenic acid, composition of ... 175
Cells, how they multiply ... 188
Climate, changes produced by ... 75
" influences of ... 76
Corn, history of ... 53, 641
Crops, philosophy of rotations in ... 147
Clay, properties of ... 154
Chlorine, properties of ... 169
Clay absorbs ammonia ... 178
Chlorine of doubtful utility ... 214
Clover, experiments with ... 236
Crops, necessity of rotation in ... 357
" how to rotate remuneratively ... 363
Clod-crusher ... 417
Coolidge, J., letter from ... 434
Corn, native country of ... 641
" in Eastern countries ... 642
" in Egyptian tombs ... 643
" different names of ... 644
" Italian ... 645
" Humboldt's opinion of origin of ... 646
" Persian history of origin of ... 647
" Summary of historical evidence ... 648
" Botanical description of ... 649
" plate illustrating flower of ... 650
" description of plate ... 651
" analyses of plant ... 652
" analyses of component parts ... 653
" matter removed from an acre ... 654
" culture of ... 655
" soil for ... 656
" Gill's experiment in deep culture ... 657
" selecting and sowing corn seed ... 658
" how to cultivate ... 659
" cultivating ... 660
" in Ohio, statement of ... 661
" varieties of ... 664
" Oregon, Fig. of ... 671
" crop of 1858 in Ohio ... 673
" crop of 1858, effects on stock ... 673

Drainage, effects of ... 403
Drainage ... 449
" how it operates ... 450
" causes independence of weather ... 451
" improves the crops ... 452
" H. F. French's statement of ... 452 to 457 inclusive

Digitized by Google

Page.
Drainage, resists drought ... 454
" prevents drought ... 455
" sundry statements on ... 456
" effects of on wheat crop ... 457
Dew, how caused ... 459
Diastase ... 134
Drilling ... 459
" saves labor ... 460
" saves seed ... 460
" produces a larger yield ... 461
" promotes tillering ... 462
" summary of advantages of ... 463
" cost of ... 464
Dillon, Isaac, letter from ... 482
Diseases of the wheat plant ... 557
" jaundice ... 559
" blight or withering ... 559
" lodging ... 560
" sprouting in the shock ... 561
" mildews ... 567
" mildews, wheat ... 572
" mildews, uredo rubigo ... 573
" mildews, uredo caries ... 575
" how to prevent ... 578
" uredo fœtida ... 579
" " " engravings of ... 580
" " rubigo vera ... 581
" " segetum ... 584
" " " how to prevent ... 587
" cladesporium herbarium ... 589
" caused by insects (see Insects) ... 592
Drop of water on first leaf of oat plant ... 223

Endosmosis defined ... 182
Exosmosis defined ... 182
Endosmotic theory untenable ... 185
Embryo ... 266

Fabre Esprit's experiment of producing wheat from ægilops ... 98
Farm-yard manure necessary ... 376
" " " value of ... 378–379
" " " drainings of ... 426, 429
" " " ammonia in ... 427
" " " analysis of ... 428
" " " drainings, composition of ... 430
" " " mineral and organic substances in ... 431
" " " quality of substances in ... 432
" " " absorbed by soils ... 433
" " " rotten draining of ... 436
" " " analysis of filtration from ... 441
" " " analysis, chemical ... 442

Digitized by Google

	Page.
Farm-yard manure before and after filtration	444
" " " for wheat	447
" " " composted	448
Flesh of elephants in river Lena	166
" of animals derived from plants	377
Flour, new method of preserving	166
" price from 1800 to 1855	328
" exported	329
Forest trees are exponents of the quality of soil	337
Fallows not essential	367
Frost, effects of on plants	465
Frozen plants, how to thaw	473
Frost, how does it act on plants?	474
Grasses, primitive	30
" history of	36
" Tropical	37
" in temperate zones	38
" geographical distribution of	39
" important	43
Granite composition	154
Grasses freeze sooner than other plants	472
German legend	11
Germination	126
" conditions necessary	129
" time of in wheat	130
" effects of colored lights on	131
" Osborne's experiments in	139
Gelc acid, analysis of	175
Gregory, D., letter from	486
Gilbert & Lawes, experiments of	239
" " history of gluten	240
" " experiments with varieties of wheat	241
" " determination of nitrogen	242
" " method of experiments	243
" " plan of investigation	244
" " summary of experiments	245
" " effect of season on crop	246
" " early wheat has less mineral matter	248
" " influence of manures	249
" " table of experiments	250
" " method of determining nitrogen	251
" " manures affect quantity more than quality	252
" " table of quantity, quality, etc	253
" " mineral manures increase nitrogen	254
" " amount of matter depends on maturity	255
" " method of analysis	256
" " probable errors as to bases	257
" " table of wheat ash. analyses (1844)	258
" " table of wheat ash, analyses (1845)	259
" " table of wheat ash, analyses (1846)	260

Digitized by Google

Page.
Gilbert & Lawes, phosphates essential to wheat 261
" " maturity depends on season 262
" " tabular statement of analyses 263
" " mean results 264
" " conclusion of experiments 265
Glume of wheat illustrated 27
Gluten, properties of 124
" composition of 199, 202
" in wheat 193
Gum, composition of 202
Gluten essential in articles of food 206
" history of discovery 240

Hendrick's, G. D., letter from on rust 590
Hopetown wheat, analysis of 120
Hornblende, composition and properties of 158
Humus, properties of 172
Humic acid, properties of 173
" " composition of 175
Humin, " " 175
Hybrids in the animal kingdom 25
" " " vegetable " 26
Hybridization, how to perform 30
Hybrids, natural in plants 33
" of wheat 34
Hybridization, Raynbird's experiments 35
" effects of 81
" Maund's and Raynbird's experiments 82
" importance of in wheat 85
Hydrogen, properties of 109

Insect diseases of wheat 592
" agrypnus murinus 592
" agriotes lineatus 593
" " obscurus 593
" " sputator 593
" anguillula tritici 632
" anisoplia agricola 594
" aphis granaria 595
" " zea 596
" athous longicollis 596
" " ruficaudis 597
" bembidium 597
" cephus pygmæus 598
" cecidomyia tritici (midge) 599
" " " fig. of 600
" " " parasites of 602
" " " how to prevent 603
" " " history of 605
" " " fig. of the male 606
" cecidomyia destructor (Hessian fly) 608
" " " fig. of 610

Digitized by Google

Page.
INSECT, cecidomyia destructor, how to prevent ... 612
" calandra granaria (weevil) ... 614
" " oryzæ ... 615
" chlorops ... 616
" " fig. of ... 617–18
" cœlinus niger ... 618
" cucujus festaceus ... 619
" gortyna zoe ... 635
" lepidotus ... 636
" micropus cucoptens (chinch bug) ... 619
" " " fig. of ... 620
" meraporous graminicola ... 616
" miris erraticus ... 621
" new insect ... 636
" noctua ... 622
" " agrotis lineolati ... 622
" oscinis ... 622
" pachymerus calcitrator ... 624
" polydesmus complanatus ... 624
" platygaster tipulæ ... 625
" " punctiger ... 607
" pteromalus nicæus ... 625
" staphylinus ... 626
" tenebrio molitor ... 626
" tinea granella ... 627
" trogosita mauritanica ... 628
" thrips cerealium ... 628
" wire worms ... 629
" zabrus gibbus ... 631
Introduction ... 9
Indian legend of grain eaters ... 10
Isomeric substances ... 138
Iron, properties of ... 155
Inorganic artificial soils ... 210
" " Salm Horstmarr's experiments in ... 210
" substances, what ones are essential ... 217
Iron, effects of in excess ... 218
" sodium and manganese necessary ... 229

LAWSON, Charles, letter of ... 132
Lime, composition and properties of ... 158
" sulphite of ... 159
" sulphate of ... 159
" phosphate of ... 159
Lignin, composition of ... 202
Lois Weedon system ... 380
" " " cost of ... 385
" " " hand labor indispensable ... 387

MAGNESIUM, properties and description of ... 160
Maple, analysis of ashes of ... 178
Manganese increases assimilation ... 213

Digitized by Google

Page.
Manganese not necessary to farm fruit..... 218
Mapes, Prof. on deep plowing..... 402
Manuring..... 426
" drainings of dung-heaps..... 426
" " ammonia in..... 427
" " analysis of..... 428
" wheat crop..... 446
Maize, native country of..... 641
" in eastern countries..... 642
" " Egyptian tombs..... 643
" various names of..... 644
Mica, composition and properties of..... 157
Mineral manures not always fertilizers..... 333
Mildew..... 567, 570
Moisture in plants..... 238
Mules or mongrels..... 25

Nitrogen, properties of..... 168
" necessity in nutrition..... 200
" what function it performs?..... 201
" in the wheat plant..... 207
" in the wheat roots..... 207
" in the wheat stalks..... 207
" in the wheat heads..... 207
" in the parts of plants collectively..... 208
" not derived from the air..... 208
" effects of..... 216
Nitrate of ammonia, effects of..... 224
Nitrogenous manures, effects of..... 353
Nutrition of the wheat plant..... 176

Organic world, general view of..... 17
Oats, history of..... 50
" experiments with..... 211, 235
Over luxuriance, effects of..... 385
Origin of vegetable and animal kingdoms..... 22
" of the wheat plant..... 92
Organic manure, value of..... 153
" " causes diseases in plants..... 355
Osborne's experiments..... 139. 191
Oxygen, properties of..... 164
" discovery of..... 165
" combinations of..... 167

Plants in different geologic eras..... 20
" changes in forms of..... 23
" impregnation of..... 29
" return to the original type..... 64
" origin of cultivated ones..... 65
" growing in high temperatures..... 127
" how do they grow?..... 176

Digitized by Google

Page.
Plants subsist on inorganic bodies..... 177
" inorganic elements in..... 179
" have inherent vitality..... 181
" do not obtain all their carbon from air..... 193
" obtain their carbon from the soil..... 196
" obtain carbon from the air, proof of..... 197
" experiments with in inorganic soils..... 210
" moisture in..... 238
" germination of..... 267
" stoma in leaves of..... 277
" do not absorb carbon in day-time..... 278
Pasture land in Ohio..... 309
Plains in Stark county, Ohio..... 343
Plants absorb food in proportion to root surface..... 375
" warmth they receive from the sun..... 467
" why some freeze so readily..... 471
Parasites, vegetable..... 565
Pistil in wheat (ill.)..... 27-28
Pitch pine, analysis of ashes of..... 178
Pollen, importance of..... 31
Potassium, properties of..... 156
Phosphoric acid..... 162
Plowing, philosophy of..... 397, 398
Plow, double..... 399
Plowing, deep..... 400
" " importance of..... 401
" " Mapes' view of..... 402
" " Yester plan of..... 404
" shallow, effects of..... 405
" deep, effects of..... 406
Paw, Geo., letter from..... 485
Plumule..... 149, 269
" function of..... 151
Physical progress.....

Quartz, composition of..... 154

Rice, history of..... 55
" culture of..... 57
Roots, physiology of..... 143
" functions of..... 144
" absorb moisture..... 183
Rust, prevented by early cutting..... 477
" in oats, what is it?..... 578
" in wheat..... 581 to 583
" G. D. Hendrick's letter on..... 590
Rye, history of..... 46
" experiments with..... 231

Straw, analysis of..... 118
Soule's wheat, analysis of..... 119

Digitized by Google

Page.
Sap, circulation of..... 185
" two circulations of..... 187
" absorption of..... 189
" produces its circulating vessels..... 190
Starch, composition of..... 202
Salm Hortemarr's experiments..... 210
" " " with white oats..... 211
" " plant flourished with nitrogen..... 212
" " lime and potash necessary..... 212
" " iron invigorates the plant..... 212
" " manganese increases assimilation..... 213
" " soda not essential..... 213
" " phosphoric acid essential..... 214
" " silicic acid necessary..... 214
" " chlorine of doubtful utility..... 214
" " comparison of experiments..... 215
" " nitrogen increases assimilation..... 216
" " experiments with seven inorganic substances..... 217
" " manganese not necessary to form fruit..... 218
" " test experiment..... 219
" " alumina, a fruit-forming substance..... 219
" " alumina, experiments with..... 220
" " alumina, experiments, with summary table of..... 221
" " cause of side shoots in oats..... 222
" " drop of water on the first leaf..... 223
" " ammonia must be in the soil before seeding..... 224
" " experiments with spring barley..... 225
" " composition of artificial soil..... 226
" " experiments with winter wheat..... 227
" " composition of artificial soil..... 228
" " experiment with nitrate of soda..... 228
" " sodium, iron and manganese necessary..... 229
" " results..... 230
" " experiments with spring barley..... 230
" " composition of artificial soil..... 230
" " experiments with winter rye..... 231
" " experiments with winter rye, barren soil..... 232-3
Season, effects of on crop..... 246
Seeding..... 458
Seed should be soaked..... 459
" " " it kills Hessian flies..... 459
" " " it prevents smut..... 459
" " " drilled..... 459
Silica, properties of..... 161
" how deposited in plants..... 273
Simmons, Hon. C. B., letter from..... 484
Spongiole..... 209, 186, 142
Soils, origin and constituents of..... 153
Sodium, properties of..... 161
Sulphuric acid, properties of..... 163
Soils change the qualities of plants..... 180

Digitized by Google

Page.
Solvent fluid ... 191
Soil absorbs carbon ... 192
Soils, why unequally fertile ... 208
Scolecit, experiment with ... 220
Sodium, chloride of, in forming fruit ... 226
Soils of Illinois ... 302
" deficiencies in Western ... 305
" of Ohio ... 307
Sheep essential on wheat soils ... 308
Soil for wheat ... 330
Soils, analyses of, not always reliable ... 334
" " of, furnish no proof of fertility ... 336
" forest trees indicate the quality of ... 337
" classification of ... 345
" clay ... 346
" sandy and lime ... 347
" marly and loamy ... 348
" composition of ... 349
" value of analyses in ... 350
" how to test lime in ... 351
" exhaustion of ... 352
" can not furnish more food than it contains ... 358
" food of plants not in solution in ... 359
" capacity for production ... 360
" " " " how to estimate ... 361
" mineral constituents removed by wheat ... 362
" exhaustion of one element exhausts all ... 364
" gradual exhaustion of ... 365
" decrease in grain forming conditions ... 369
" progressive exhaustion of ... 373
Smith's, Rev., system of wheat-growing ... 389
Soil, pulverization of the ... 383
" management of ... 389
" best for wheat ... 390
" frequent plowing necessary ... 391, 393
" pores in ... 392
" capillary attraction in ... 394
" Salisbury's experiment ... 395
" soluble salts on clay ... 396
" must be comminuted ... 397
" Dr. Madden on pulverization ... 415
" mechanical relations of ... 420
" lack of air and moisture in ... 421
" conditions of illustrated ... 422
" excess of water in ... 423
" effects of drainage ... 424
" improvement of ... 426
" absorbing powers of ... 433, 435
" analyses of ... 434
" absorb potash from manures ... 438
" absorb phosphates from manure ... 439

Digitized by Google

Page.
Soils, all do not readily absorb 445
" moisture in 453
" color changes temperature 466
Shocks, best method of making 563
Summer wheat, analyses of 114
Sugar made of starch 130
Sugar 202
Smut in wheat 572
" in wheat 584
" " how to prevent 587

TILLERING 271
Tobacco plant requires saltpeter 179
" experiments with 236
Tull's, Jethro, system of wheat-growing 380

UNGER'S theory of the vegetable kingdom 21
Ulmin, composition of 175
Ulmic acid, composition of 175

VEGETABLE molds 345
Vegetables, how to thaw, when frozen 473
Vine requires lime 179
Vital force in plants 183
Vicia sativa, experiments with 234
Vines, why pruning is necessary 370

WAX, composition of 202
Weighman's & Polstorf's experiments 233
" " composition of artificial soil 233
" " experiment with vetches 234
" " " " barley 234
" " " " oats 235
" " " " buckwheat 235
" " " " tobacco 236
" " " " red clover 236
" " analyses of ashes of above plants 237
Western Reserve, adaptation of 311
West, the, not a wheat region 325
Wheat the symbol of civilization 9
" plant never leaves civilization 13
" " history of 59
" in ancient Egypt 61
" wild in Oregon and California 62
" first in Mexico 63
" varieties of 66
" " change by culture 68
" does it change to chess? 69
" turning to chess, report on 73
" and chess will not hybridize 74
" Australian, changes in 76

Digitized by Google

	Page.
Wheat, structure of grain	77
" origin of varieties	78
" does not hybridize in the field	79
" importance of hybrids	85
" history of Mediterranean	87
" Le Couteur's experiments with	91
" origin of	92
" produced from ægilops	100
" grain, structure and composition of	107
" " analysis of	108
" " " Beck's	109
" " " Emmon's	110
" " structure of	120
" plant germination	126
" " life of in different countries	128
" embryology of	133
" can grow in poison	141
" plant, nutrition of	176
" " requires phosphates	179
" gluten in	199
" winter, S Horstmarr's experiments with	227
" spring, experiments with	230
" Gilbert & Lawes's experiments	241
" nitrogen in	242
" plant, growth of	266
" " germination of	267
" " proper depth to plant	270
" " tillering, process of	271
" " winter killing	273
" " result of drought	274
" grains not productive without impregnation	279
" plant, botanical description of	280
" head, anatomy of	281
" "breast," anatomy of	282
" glume, anatomy of	283
" pollen, its properties and uses	284
" pistil, anatomy and function of	285
" plant tillers from coronal roots only	286
" " its remarkable tillering powers	287
" regions of the world	290
" regions of Europe	291
" produced in Europe	292
" flour imported by Britain	293
" trade of the Elbe and France	294
" " of Spain	295
" " of Odessa	296
" regions of the U. S	297
" average crops in U. S	298
" crops in each State	299
" regions of the West	300
" " deterioration of	301

Digitized by Google

Page.
Wheat regions of Illinois 302
" soils of Illinois 303
" section of U. S. 306
" soil of Ohio 307
" acres of, sown in Ohio from 1850 to 1857 312
" bushels gathered in Ohio from 1850 to 1857 316
" loss by insects in Ohio 320
" district in Ohio changing 321
" " diminution of 323
" average product of in Ohio 324
" region, Ohio the center of 327
" amount exported 329
" culture of 330
" soils, Scotch method of determining 344
" after clover 354
" amount of mineral matter removed in an acre 362
" to precede potatoes 371
" rotation with clover and potatoes 372
" how to grow with profit 381
" crop, manuring 446
" for seed should be soaked 459
" bearded most liable to freeze 470
" when to harvest it 475
" advantages of early cutting 476
" description and classification of varieties 479
" transmutation of species 481
" color no basis of classification 487
" Metzger's classification of 488
" common varieties of 488
" turgid varieties of 489
" hard varieties of 489
" Polish 489
" Speltz 490
" Emmer or Amel corn 491
" St. Peter's corn 491
" in New York, Emmon's classification 492
" spring varieties in New York 494
" additional varieties in New York 495
" British varieties 496
" " Lawson's classification 497
" " description of ..... 498 to 511
" varieties in Ohio 512
" " bearded winter, red ..... 512 to 525
" " smooth winter, red ..... 525 to 533
" " bearded winter, white ..... 533 to 537
" " smooth winter, white ..... 537 to 551
" " spring ..... 551 to 556
" diseases and enemies of 557
" " atmospheric 559
" degeneration of 565
" vegetable parasites of 567

Digitized by Google

Page.
Wheat, insect parasites of..... 592
Winter wheat, analysis of..... 116
White flint wheat, analysis of..... 118
Wheatland red wheat, analysis of..... 118
White oats, experiments with..... 211
Woodland in Ohio..... 309

YESTER deep land culture..... 404
" " " " effects of..... 406
" " " " effects of mucking..... 409
" " " " effects on crops..... 410
" " " " effects on hay crop..... 414
" system saves labor..... 415

Digitized by Google

PRACTICAL LANDSCAPE GARDENING.

By G. M. KERN. *Containing Twenty-two Illustrations and Plans for laying out Grounds, with full directions for Planting Shade Trees, Shrubbery and Flowers. Third Edition. One volume, 12mo., Muslin. Price, $1 50.*

Mr. Kern has produced the right book at the right moment.—Putnam's Magazine.

His suggestions are in an eminent degree valuable, and his opinions (which are expressed in clear, concise, and lucid diction), easily interpreted by even the most limited conception, fairly assert his claim to a station in the foremost rank of rural improvers.—N. Y. Horticulturist.

It abounds in useful and tasteful suggestions, and in practical instructions.—Northern Farmer.

It is a very timely and valuable book. . . . . Better adapted to the wants and circumstances of our people than any other upon the subject.—Ohio Cultivator.

No one can long walk hand in hand with Mr. Kern without being sensible that he is in the hands of one who is worthy of all confidence.—Louisville Courier.

Has so nobly succeeded as to render his volume an invaluable acquisition to all.—Boston Traveler.

It is plain in its details, and will be more valuable to the million than any work on the subject of Landscape Gardening yet published. The mechanical execution of the volume is the very perfection of printing and binding.—Ohio Farmer.

Admirably calculated to meet the wants of the public.—Boston Atlas.

By a careful perusal of this little volume, which will cost but $1 50, the purchaser will probably find that he has learned what he has been all his life wishing to know, and what will be worth to him more than ten times its cost.—Nashville Whig.

He descends to the minutest details of instruction, so that his book may be taken as a manual for the practical operator.—N. Y. Evangelist.

GRAPE AND STRAWBERRY CULTURE.

The Culture of the Grape and Wine Making. By ROBERT BUCHANAN. *With an Appendix, containing Directions for the Cultivation of the Strawberry. By* N. LONGWORTH. *Sixth Edition. One volume, 12mo., Muslin. Price, 63 cents.*

It contains much opportune and instructive information relative to the cultivation of these two delicious fruits.—Michigan Farmer.

One of the books which pass current through the world on account of the great authority of the author's name.—Hoboken Gazette.

There are no men better qualified for the undertaking.—Louisville Journal.

It deals more with facts, with actual experience and observation, and less with speculation, supposition and belief, than any thing on this topic that has yet appeared in the United States. In other words, a man may take it and plant a vineyard, and raise grapes with success.—Horticulturist.

We can not too strongly recommend this little volume to the attention of all who have a vine or a strawberry bed.—Farm and Shop.

This book embodies the essential principles necessary to be observed in the successful management of these fruits.—Boston Cultivator.

We have on two or three occasions said of this little book, that it is the best we have ever seen on the subjects of which it treats. A man with ordinary judgment can not fail in grape or strawberry culture, if he tries to follow its advice.—Ohio Farmer.

HOOPER'S WESTERN FRUIT BOOK.

A Compendious Collection of Facts, from the Notes and Experience of Successful Fruit Culturists. Arranged for Practical use in Orchard and Garden. One vol., 12mo., with Illustrations. Price, $1 00.

Three thousand copies of this work have already been disposed of.

Digitized by Google

Published by Moore, Wilstach, Keys & Co.

BAYARD TAYLOR'S
CYCLOPEDIA OF MODERN TRAVEL.

A Record of Adventure, Exploration and discovery for the past fifty years. Comprising Narratives of the most distinguished Travelers since the beginning of this Century. Prepared and arranged by Bayard Taylor. *1 vol. royal 8vo. 950 pages. Embellished with fine portraits on steel by Butre, and illustrated by over forty wood engravings by Orr, and thirteen authentic Maps by Schonberg.*

A magnificent octavo volume, which for general interest and value, is worthy of the distinguished compiler, and equally worthy of universal patronage. The volume really contains the value of a whole library, reliable as a book of reference, and as interesting as a book of romance.—*Springfield (Mass.) Republican.*

The popular lectures and writings of Bayard Taylor, have awakened in the United States a thirst for information respecting foreign countries and nations. A striking proof of this is given in the fact that a publishing house in Cincinnati, have issued under the auspices of Bayard Taylor, a volume of nearly one thousand pp., devoted exclusively to records of travel. These Reports are perfectly reliable; the matters of fact of each explorer, often in his own language, are condensed into a consecutive narrative, by the most competent living author in the same department.—*N. Y. Independent.*

The reading public owes to Bayard Taylor many a debt for rare and valuable instruction, most agreeably conveyed; but we doubt if he ever performed a more useful service than in compiling this massive, varied and most valuable volume. The entire circle of books of which he has given the spirit and juice, would form a library; and many of them are now almost inaccessible. Mr. Taylor's part has been conscientiously done. It is not merely a work of selection and groupings; much of it is his own statement of the results more voluminously given, and written in a clear and elegant style. We can not but regard it as a very useful as well as entertaining work, well adapted to communicate accurate and comprehensive views of the world, and supplying for families an almost inexhaustible fund of pleasant reading.—*N. Y. Evangelist.*

No writer of the present age can be found so admirably qualified for such an undertaking.—*Louisville Journal.*

Such is the full title-page of a magnificent octavo volume of 956 pages, just issued. * * * We said "a magnificent octavo." It is so whether we consider its contents, or the superb style in which the publishers have gotten it up. It is just the book for the family library; all classes will be interested in its perusal.—*Ladies Repository.*

The conception of this work is admirable; and its execution is what might be expected from one of the most accomplished and intelligent travelers of the age. * * * It is remarkable for compactness, condensation and symmetry; and whoever will take the time to read it through, will possess himself of an amount of information, in respect to the physical, intellectual, and moral condition of almost every portion of the globe, which he can scarcely expect to find elsewhere. The work is illustrated with a large number of maps and engravings, which are executed with great skill and care, and add much to the interest of the narratives to which they are prefixed.—*Puritan Recorder.*

Mr. Bayard Taylor is the very Ulysses of modern tourists, and Emperor Adrian of living ramblers—and so is qualified to edit, or compile from the works of other travelers. * * * It is but the merest justice to say, that Mr. Taylor has done all that even an uneasily satisfied reader could expect, to produce a capital book.—*Boston Chronicle.*

Apart from the confidence inspired by the name of the writer, it needs but a brief explanation of its contents to show that it forms a highly important addition to the family library. Its pages are crowded with interesting information.—*N. Y. Tribune.*

From Professor C. C. Felton of Harvard University.

A scholar, traveler and writer, having a reputation so deservedly high in this threefold relation as Bayard Taylor, may be presumed to give his name only to works worthy of it. The present volume I have examined carefully, and have read a considerable part of it; and I have found it prepared and arranged with excellent judgment, and filled with matter of the highest interest and value. Both the plan and execution are in my judgment marked by ability, extensive knowledge, good taste, and good sense.

From Oliver Wendell Holmes, M. D., Author of "The Autocrat of the Breakfast Table," etc.

Mr. Bayard Taylor has done the reading public a great favor in bringing together the most essential and interesting portions of so many narratives within a very moderate compass, and in such a form as to be accessible to multitudes whose libraries must take little room and cost but moderate expenditure. It is safe to say that no man's selection would be accepted so unhesitatingly in America as those of our own favorite travel story-teller.

From Hon. Robert C. Winthrop, of Boston, formerly Speaker House of Representatives, U. S

I have examined it with great interest. It contains a large amount of entertaining and instructive matter, very conveniently and carefully arranged; and I shall value it as a work both for present reading and future reference.

Digitized by Google

We recommend all the boys in the land to get these books and read them.—Pittsburg Gazette.

MAN-OF-WAR LIFE,

A Boy's Experience in the United States Navy. By CHARLES NORDHOFF. *Seventh Edition. One volume, 16mo., illustrated. Muslin, 75 cents. Muslin, gilt, $1.*

THE MERCHANT VESSEL,

A Sailor Boy's Voyage to See the World. By CHARLES NORDHOFF. *Seventh Edition. One volume, 16mo., illustrated. Muslin, 75 cents. Muslin, gilt, $1.*

WHALING AND FISHING.

By CHARLES NORDHOFF, *Author of "Man-of-War Life," "The Merchant Vessel," etc. One volume, 16mo., illustrated. Muslin, 75 cents.*

A writer who is destined to cheer the family circle in many thousand houses on many a winter night. He writes well—admirably; that is, simply and truthfully, and in a very interesting way indeed. He tells the story of the vicissitudes, as well as the pleasures, of the life of the boy or man before the mast, so that no youth who longs to be on the "deep blue sea" may hereafter say that it was out of his power to learn precisely what he would have to encounter on becoming a sailor. The moral of the work is excellent, and its style pithy and descriptive.—Washington Star.

Full of variety, and adapted to awaken the interest of young people in traveling adventure, while it must greatly extend their geographical knowledge.—N. Y. Times.

Very striking and graphic pictures of the life at sea, evidently authentic and very instructive. . . . Has adventure enough to please, yet truth enough to dissipate the charm of a sailor's life.—N. Y. Evangelist.

There is in them a vast amount of information respecting the commerce of the world.—Presbyterian Witness.

These books are not for mere children, but for lads of some years and discretion. They are remarkably well written.—N. Y. Independent.

One of the best and truest descriptions of seamen and of a seaman's life ever given to the public, and the reader is only left to wonder why one who can write so remarkably well, had ever any thing to do with the rigging. . . . . He describes the various countries which he visited so far only, be it remembered, as they fell under his own observation—and this careful restriction and regard to the truth forms one of the principal charms of the works.—Boston Traveler.

Has a fine eye for observation and excellent descriptive powers.—Louisville Cour.

Multitudes of young readers will delight in these books.—Presbyterian Banner.

Since Dana's "Two Years Before the Mast," we do not call to mind any more admirable descriptions of a sailor's life at sea than are contained in these graphic volumes. Herman Melville's nautical narratives are more highly spiced with piquant descriptive scenes, it is true, but for quiet, absorbing, and, as far as landsmen can judge, faithful accounts of life on shipboard, commend us to this anonymous author. He somewhat resembles Capt. Basil Hall in his lively pictures of the routine of sea service, but he is not so rambling nor so flippant as that celebrated "old salt."—N. Y. Tribune.

It (Man-of-War Life) is excellently well written, is characterized by a high moral tone, and impresses the reader with the truthfulness of its sketches, while it has all the fascination of a romance. It is by far the best book for boys that we have ever seen. It both instructs and amuses them. Indeed, there are few men who will commence this book and lay it down unfinished.—Lexington Ky., Statesman.

Mr. Nordhoff is a young writer who has seen every variety of sea life, from the artistic organization of the Man-of-War to the rough and tumble arrangements of a Nantucket whaler; and without assuming any of the airs of authorship, has given a strait-forward account of his adventures, which, in frank confiding naturalness, are not without something of the secret charm which so bewilders all classes of readers in the perusal of works like Robinson Crusoe. Not that he makes use of any imaginary touches to add to the piquancy of his autobiographical confessions, but he has the rare gift of investing every day realities with an atmosphere of human sympathy which is more effective than the most dazzling colors of romance.—Harper's Magazine.

Digitized by Google

RENOUARD'S HISTORY OF MEDICINE.

A History of Medicine, from its Origin to the Nineteenth Century, with an Appendix, containing a series of Philosophic and Historic Letters on Medicine of the present Century, by Dr. Renouard, Paris. Translated from the French, by C. G. Comegys, Prof. Inst. Med. in Miami Medical College. One volume octavo. Sheep. Price, $3 50.

SYNOPTIC TABLE OF CONTENTS:

I. AGE OF FOUNDATION. 1. PRIMITIVE PERIOD: From the Origin of Society to the Destruction of Troy, 1184, B. C. 2. SACRED OR MYSTIC PERIOD: Ending with the Dispersion of the Pythagoreans, 500, B. C. 3. PHILOSOPHIC PERIOD: Ending at the Foundation of the Alexandrian Library, 320, B. C. 4. ANATOMICAL PERIOD: Ending at the Death of Galen, A. D. 200. II. AGE OF TRANSITION. 5. GREEK PERIOD: Ending at the Burning of the Alexandrian Library, A. D. 640. 6. ARABIC PERIOD: Ending at the Revival of Letters in Europe, A. D. 1400. III. AGE OF RENOVATION. 7. ERUDITE PERIOD: Comprising the Fifteenth and Sixteenth Centuries. 8. REFORM PERIOD: Comprising the Seventeenth and Eighteenth Centuries.

From Professor Jackson, of the University of Pennsylvania.

PHILADELPHIA, May 1.

My Dear Sir—The work you have translated, "Histoire de la Medecine," by Dr. P. V. Renouard, is a compendious, well-arranged treatise on the subject.

Every physician and student of medicine should be acquainted with the history of his science. It is not only interesting, but of advantage to know the views and the interpretations of the same pathological conditions investigated at the present day, in past ages. They were handled then with as much force and skill as now, but without the scientific light that assists so powerfully modern research. . . .

Very truly yours, SAMUEL JACKSON.

The best history of medicine extant, and one that will find a place in the library of every physician who aims at an acquaintance with the past history of his profession. . . . . There are many items in it we should like to offer for the instruction and amusement of our readers.—American Journal of Pharmacy.

From the pages of Dr. Renouard, a very accurate acquaintance may be obtained with the history of medicine—its relation to civilization, its progress compared with other sciences and arts, its more distinguished cultivators, with the several theories and systems proposed by them; and its relationship to the reigning philosophical dogmas of the several periods. His historical narrative is clear and concise—tracing the progress of medicine through its three ages or epochs—that of foundation or origin, that of tradition, and that of renovation.—American Journal of Medical Science.

Is a work of profound and curious research, and will fill a place in our English literature which has heretofore been vacant. It presents a compact view of the progress of medicine in different ages; a lucid exposition of the theories of rival sects; a clear delineation of the changes of different systems; together with the bearings of the whole on the progress of civilization. The work also abounds in amusing and instructive incidents relating to the medical profession. The biographical pictures of the great cultivators of the science, such as Hippocrates, Galen, Avicenna, Haller, Harvey, Jenner, and others, are skillfully drawn. *Dr. Comegys deserves the thanks of not only the members of the medical profession, but also of every American scholar, for the fidelity and success with which his task has been performed.*—Harper's Magazine.

From the British and Foreign Medico-Chirurgical Review, for July, 1857.

HISTORY OF MEDICINE.—It is expressly from the conviction of the deficiency of the English language in works on the History of Medicine, that we feel indebted to Dr. Comegys for the excellent translation of the comparatively recent work of Renouard, the title of which is placed at the head of this article. . . . . We hope before long to find that in every important school of medicine in this country, opportunities will be offered to students whereby they may be enabled to attain some knowledge at least of the history of that profession to the practice of which their lives are to be devoted.

Digitized by Google

PULTE'S TESTE ON DISEASES OF CHILDREN.

A Homœopathic Treatise on the Diseases of Children. By ALN. TESTE, *Doctor in Medicine, Member of several learned Societies, etc. Translated from the French, by* EMMA H. COTE. *Second Edition. Revised by* J. H. PULTE, M. D. *One volume, 12mo., muslin. Price, $1 25.*

It is the only treatise on the Homœopathic plan expressly devoted to the diseases of children. With great completeness of detail, it describes the principal diseases to which that age is subject, together with their appropriate remedies. As a manual of domestic practice, it must be welcome to the receivers of Hahnemann's system.—N. Y. Tribune.

This is an excellent work. . . . . It is distinguished by clearness of statement, practicalness of direction, and by originality of observation. What renders it particularly valuable to families is the simplicity of its directions, obviating the doubt and uncertainty which attend the attempt to administer medicines according to most Homœopathic works.—Cleveland Leader.

CROSERIO'S OBSTETRICS.

A Homœopathic Manual of Obstetrics: or a Treatise on the Aid the Art of Midwifery may derive from Homœopathy. By DR. C. CROSERIO, *Medecin De l' Embassade De Sardaigne, Membre De La Societe Hahnemannienne De Paris, etc., etc. Translated from the French, by* M. COTE, M. D. *Second Edition. One volume, 12mo., muslin. Price, 75 cents.*

It is only necessary to have it known that Dr. Croserio is the author of the above work, to induce each practitioner of our school to seek a copy of it without delay. It is one of those few practical works which will aid practitioners at the bedside of the sick. . . . . The volume may seem insignificant, because it contains only 153 pages; but our readers can hardly conceive of the amount of information which the author has contrived, in the clearest manner, to express in a few words. . . . . The practice is purely Homœopathic.—American Journal of Homœopathy.

. . . . Shows what Homœopathy has done, and can do. . . . We take pleasure in recommending it to Homœopathists.—North-West. Journal of Hom.

Having read the original, we can pronounce this a good translation. . . . . We think it a very excellent work: such a book as has long been needed in Homœopathic practice, one manifesting in itself a great deal of close and patient study and research.—Philadelphia Journal of Hom.

RAPOU ON FEVER.

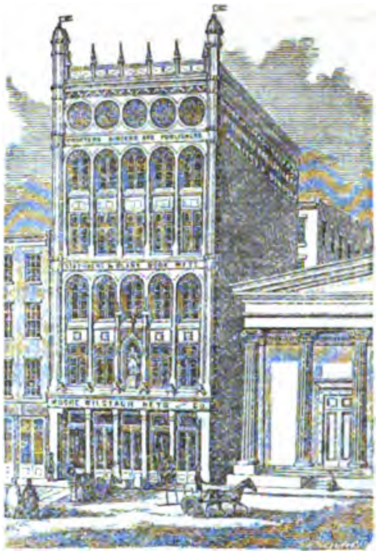
Typhoid Fever and its Homœopathic Treatment. By AUG. RAPOU, *Docteur en Medecine De Faculte De Paris. Translated by* M. COTE, M. D. *One volume, 12mo., muslin. Price, 50 cents.*

The original work, of which this volume is a translation, is understood by the students of Homœopathy to be one of the most valuable treatises on the subject that exists in medical literature. It contains many original and striking views on the characteristics of fever in general, while its practical directions in regard to the specific disease of which it treats, can not fail to suggest important hints to the intelligent practitioner of every school. An interesting feature of this volume is a spirited discussion of the use of blood-letting, and of water in the cure of typhoid fever. The translation, which is from the pen of an eminent Homœopathic physician in Pittsburg, presents the views of the writer in neat and compact English. In the prevailing uncertainty of the profession with regard to the fatal scourge, to which this work is devoted, its lucid reasonings, must prove acceptable to a wide circle of medical readers.—New York Tribune.

Digitized by Google

MOORE, WILSTACH, KEYS & CO.,

25 WEST FOURTH STREET, CINCINNATI.



Publishers, Booksellers, Stationers, Printers, Binders,

AND MANUFACTURERS OF PAGED BLANK BOOKS, ETC.

☞ WHOLESALE BUYERS are specially invited to call upon us.

JUST PUBLISHED.

I.

THE TEACHERS' INDICATOR AND PARENTS' MANUAL,

FOR

SCHOOL AND HOME EDUCATION.

We need scarcely vouch for the real sterling value of this volume, as it consists of elaborate essays on topics covering nearly the whole field of Education, from the pens of some of the most distinguished men in the country. 1 vol. 12mo., 450 pages, beautifully printed on fine paper, price $1.25.

II.

THE SCIENCE OF EDUCATION AND ART OF TEACHING,

IN TWO PARTS,

BY JOHN OGDEN, A. M.

III.

THE ART OF ELOCUTION,

BY H. N. DAY, A. M.,

Author of "Elements of the Art of Rhetoric," and formerly Professor of Rhetoric in "Western Reserve College," now President of "Ohio Female College."

June 1st, 1[illegible]

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

HW 28D2 B

The borrower must return this item on or before the last date stamped below. If another user places a recall for this item, the borrower will be notified of the need for an earlier return.

Non-receipt of overdue notices does ***not*** *exempt the borrower from overdue fines.*

Harvard College Widener Library
Cambridge, MA 02138 617-495-2413

WIDENER
DEC 19 2000
NOV 14 2000
MAR 19 2001
BOOK DUE
CANCELLED

WIDENER
WIDENER
APR 10 2001
MAR 19 2001
BOOK DUE
CANCELLED

Please handle with care.
Thank you for helping to preserve library collections at Harvard.

Digitized by Google